

TEST GUIDE FOR DATA CENTER TIME RECEIVER, BOUNDARY CLOCK AND TRANSPARENT CLOCK TIME ERROR MEASUREMENT

Stefano Ruffini, Calnex Solutions

Eric Percival, Calnex Solutions

Brandon Frech, Calnex Solutions

Version History

Date	Version #	Author	Description
13 FEB 26	1.0	Stefano Ruffini Eric Percival Brandon Frech	Created and outlined test guide

Date: February 2026

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Executive Summary

This guide describes methods for verifying clock accuracy to predefined limits that can be applied to clocks used for datacenter applications. The document is developed within the Open Compute Project (OCP) Timing Appliances Project community (https://www.opencompute.org/wiki/Time_Appliances_Project).

This version of the test guide focuses on time receivers, boundary clocks, and transparent clocks. Future versions of the test guide may also include grandmasters. The performance metrics are based on Telecom applications (i.e., referring to ITU-T recommendations), that can be considered as consistent with some of the most stringent classes of requirements also applicable in datacenters.

Date: February 2026

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Table Of Contents

Contents

Version Table 2
Executive Summary 3
Table Of Contents 4
1. Introduction 6
1.1 Device Descriptions 7
1.1.1 Boundary Clocks 7
1.1.2 Transparent Clocks 7
2. Compliance with Open Compute Project Tenets 8
2.1 Openness 8
2.2 Efficiency 8
2.3 Impact 8
2.4 Scale 8
2.5 Sustainability 8
3. Definitions 9
4. Hardware and Software Requirements 10
5. Connecting TA Analyzer with Time Receiver and Boundary Clocks for Noise and Holdover Tests 11
6. Connecting TA Analyzer with Transparent Clocks for Noise Tests 13
7. Noise Generation Test 14
7.1 Time Receiver and Boundary Clocks 14
7.2 Transparent Clocks 17
8. Noise Tolerance Test 20
8.1 Time Receiver and Boundary Clocks 20
8.2 Transparent Clocks 21
9. Noise Transfer Test 22
9.1 Time Receiver and Boundary Clocks 22
9.2 Transparent Clocks 23
10. Holdover Test (applicable to Time Receiver and Boundary Clocks) 24
11. Connecting TA Analyzer with a Clock for Transient Tests 25
12. Transient Tests 26
12.1 Time Receiver and Boundary Clocks 26

Date: February 2026

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

12.2 Transparent Clocks....27
13. Conclusion....28
14. References....29
15. License....30
15.1 Creative Commons....30
16. About Open Compute Foundation....31

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

1. Introduction

Time Receiver (previously and elsewhere referred to as Slave Clock, Subordinate Clock, PTP Client, etc.), Boundary Clock and Transparent Clock accuracy is essential to the successful operation of distributed data centers and other industries that depend on accurate time. The degree of accuracy required will vary from industry to industry – however the methods for testing can be similar for most if not all.

This guide offers methods for verifying clock accuracy to some predefined limits. It is based on the methodologies defined in **ITU-T G.8273.2 - Timing characteristics of telecom boundary clocks and telecom time slave clocks for use with full timing support from the network**, and **ITU-T G.8273.3 - Timing characteristics of telecom transparent clocks for use with full timing support from the network** using a suitable Timing Accuracy Analyzer.

Note - Specific test limits for data centers are being defined as part of an ITU-T Supplement G Suppl.DCSync. Various classes are being considered, the values presented in this document should be consistent with one of these classes. Less demanding requirements might be met in partial timing support or in full timing support and with transparent clocks operating with PTP/IP and potentially creating asymmetries.

The limits for individual devices are derived from the end-to-end timing requirements. For example, in the 4G and 5G cellular networks covered by the ITU standards, there is a base station to base station maximum time difference requirement of 3µs. This is implemented as a ±1.5µs limit to each base station from the time reference. The 1.5µs budget is divided up across all the devices between the system time reference and the base station antenna – with different classes of performance being defined depending on how many hops are required.

Other industries will have different needs – but the principles are the same.

This Test Guide describes how a Timing Accuracy Analyzer, can be used to prove a clock's compliance with the test limits for each of following parameters.

1. Noise Generation
2. Noise Tolerance
3. Noise Transfer
4. Transient Response
5. Holdover Performance

Date: February 2026

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

1.1 Device Descriptions

1.1.1 Boundary Clocks

Boundary clocks (BC) consist of two parts – a time receiver which is connected to an upstream time provider and a time transmitter which is connected to one or more downstream devices.
They work by locking their time receiver to the upstream clock while applying appropriate filtering then using the output from the receiver to discipline their internal clock for the purpose of generating a new timing signal with (hopefully) less noise than the input signal.

1.1.2 Transparent Clocks

Transparent clocks (TC) aim to minimize the time error in a synchronization system device such as a router by measuring the residency time of PTP event messages within the device and including this time within the Correction Field of the associated messages.

How effective they are depends on how accurately they can measure this residency time.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

2. Compliance with Open Compute Project Tenets

2.1 Openness

This test guide outlines a general methodology to measure the clock accuracy of a device and the necessary metrics to observe. It can be applied to any applicable device and any timing accuracy analyzer can be used that adheres to the hardware and software requirements.

2.2 Efficiency

Increased time synchronization in a datacenter leads to better coordination of distributed systems. This leads to an overall improved performance and availability. Time receivers, boundary clocks, and transparent clocks greatly improve this synchronization but need to be tested to ensure they are operating correctly to maximize efficiency.

2.3 Impact

The precision time protocol and supported devices are increasingly being deployed across datacenters, however, there is a lack of transparency regarding how well this synchronization is working. This guide will enable anyone to measure and verify the clock accuracy to ensure their expected performance benefits are being achieved. This can be used to correlate infrastructure choices with cost savings.

2.4 Scale

As datacenters increase in scale the benefits of time synchronization become more apparent. This methodology can be used on all relevant devices being placed in datacenters to ensure bottlenecks or failure points are not being introduced into a large-scale network.

2.5 Sustainability

This guide will lead to the ability to run distributed systems with better efficiency. Therefore, the same amount of equipment can be used with better performance. This leads to the need for less hardware to be deployed in datacenters resulting in greater energy efficiency and a decrease in technological waste.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

3. Definitions

DUT – Device Under Test

Time Error – the difference between the reference time and the time measured at the DUT. It is calculated as Tmeas – Tref.

Constant Time Error (cTE) – the mean time offset between the reference and the DUT – typically caused by delay asymmetry between the forward and reverse paths between the Time Transmitter and the Time Receiver.

Dynamic Time Error (dTE) – the variable component of the Time Error, typically caused by Packet Delay Variation (PDV) and timestamping variation.

Noise Generation – how much time error is measured at the output of the Time Receiver or Boundary Clock when a perfect input is applied.

Noise Tolerance – how much dynamic time error can be applied to the input of a device before it fails.

Noise Transfer – how much time error is measured at the output of the Time Receiver or Boundary Clock when an imperfect input is applied.

Transient Response – How does the clock perform when a transient – e.g., a step – is applied to the input, perhaps as the result of a network rearrangement.

Holdover Performance – How does the clock perform when the source of input time or frequency is removed.

Free-run Performance – How does the clock perform when the clock has never been locked, or the source of input time or frequency has been lost for a longer period of time and the device is no longer in holdover.

Sync-E – Synchronous Ethernet, defined in ITU G.8261. This is a method for transferring frequency over Ethernet. It is required by G.8273.2 but is optional in this context.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

4. Hardware and Software Requirements

The Time Accuracy Analyzer should have the following functionality.

Time Error Measurement

- Able to perform as both a Time Transmitter and Time Receiver Clock at the same time.
- Compliance and compatibility with IEEE1588-2008 [and IEEE1588-2019] features and applicable PTP profiles.
  Note – 1588-2019 features over and above those in 1588-2008 are optional.
- Ability to impose wander impairments into the Tx line transmitting PTP.
- Capability to capture the incoming PTP traffic from the DUT where relevant.
- Ability to measure the time accuracy of the 1pps output from the DUT against a suitable reference.
- Ability to read Time of Day (ToD) output from the DUT.

For Testing Devices that Utilize SyncE

- Ability to impose wander impairments into the SyncE frequency line.
- Ability to generate and control the content of outgoing SyncE ESMC packets.
- Capability to capture the incoming ESMC packets from the DUT.
- Ability to measure the SyncE wander.

Analysis Software

- Able to analyze and display the time and frequency error results in appropriate formats.
- Able to indicate limits and when they have been exceeded.

Accessories

- Optical/Electrical device interfaces.
- Cables and adapters required for connecting the DUT to the Analyzer.
  Note - Adapters may be needed for the use of 1pps accuracy/time error measurements.
- Frequency Reference Source e.g. common external reference or a disciplined Rubidium source.
- 1pps Reference Source

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

5. Connecting TA Analyzer with Time Receiver and Boundary Clocks for Noise and Holdover Tests

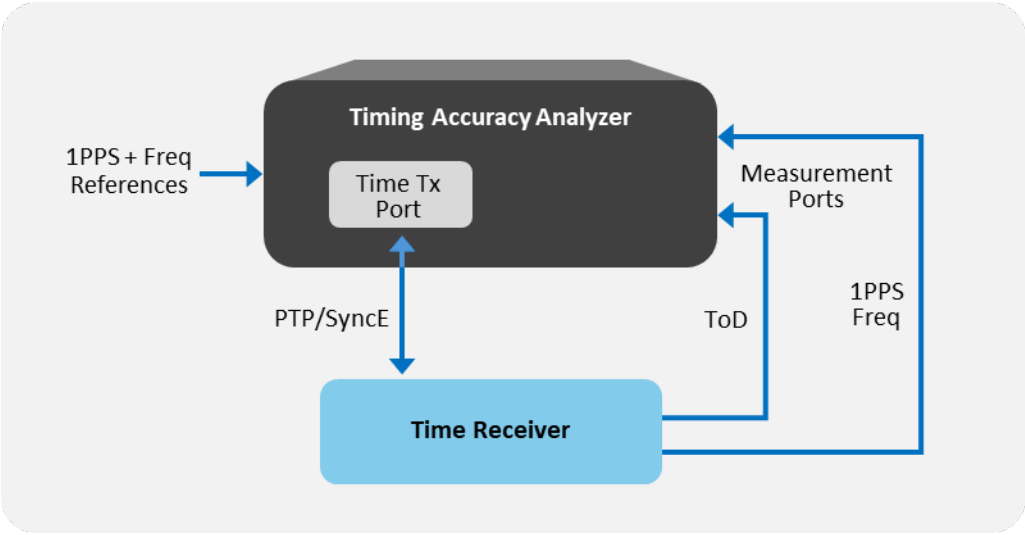


Figure 1-Time Receiver Connections for Noise and Holdover Tests

1. Connect the Network Analyzer PTP Time Transmitter Port to the Time Receiver Port
2. Connect external references to the Network Analyzer Reference inputs
3. Connect the Time Receiver 1pps output to the the Network Analyzer 1pps Input Port
4. Connect the Frequency output from the Time Receiver to the Network Analyzer Frequency Input Port

   Refer to Analyzer Manual for detailed instructions on set-up and connections

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

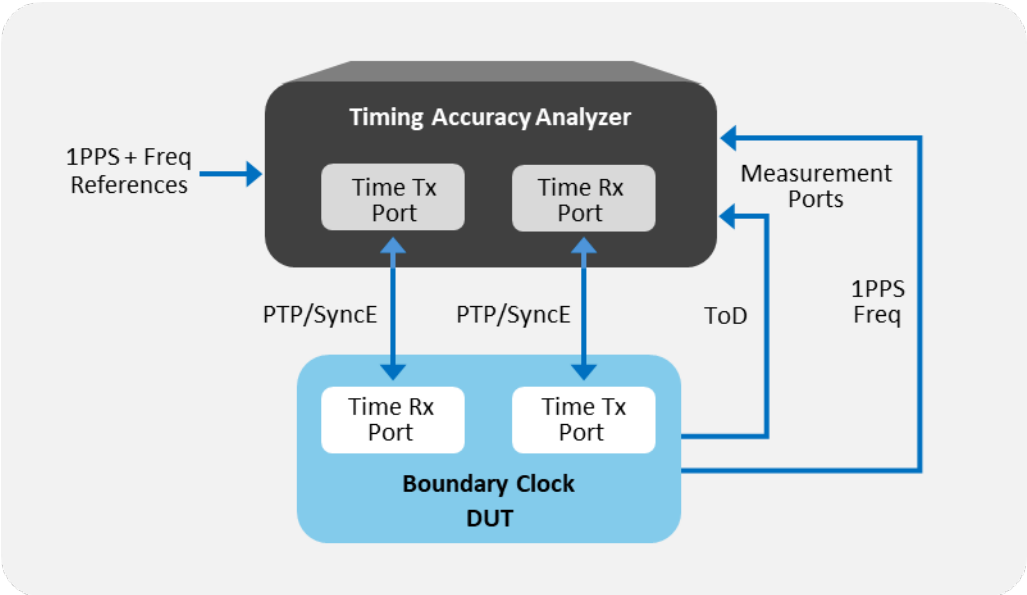


Figure 2-Boundary Clock Connections for Noise and Holdover Tests

1. Connect the Analyzer PTP Time Transmitter Port to the BC Time Receiver Port
2. Connect the Analyzer PTP Time Receiver port to the BC Time Transmitter Port
3. Connect external references to the Analyzer Reference inputs
4. Connect the BC Time Receiver 1pps output to the Analyzer 1pps Input Port
5. Connect the BC time Receiver Frequency output to the Analyzer Frequency Input Port

Refer to Analyzer Manual for detailed instructions on set-up and connections

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

6. Connecting TA Analyzer with Transparent Clocks for Noise Tests

Note – G.8273.3 specifies testing of Transparent Clocks that are syntonized using Sync-E. Sync-E is optional in this context and frequency transfer noise testing is not included in this document. Refer to G.8273.3 for further information on frequency transfer noise testing if required.

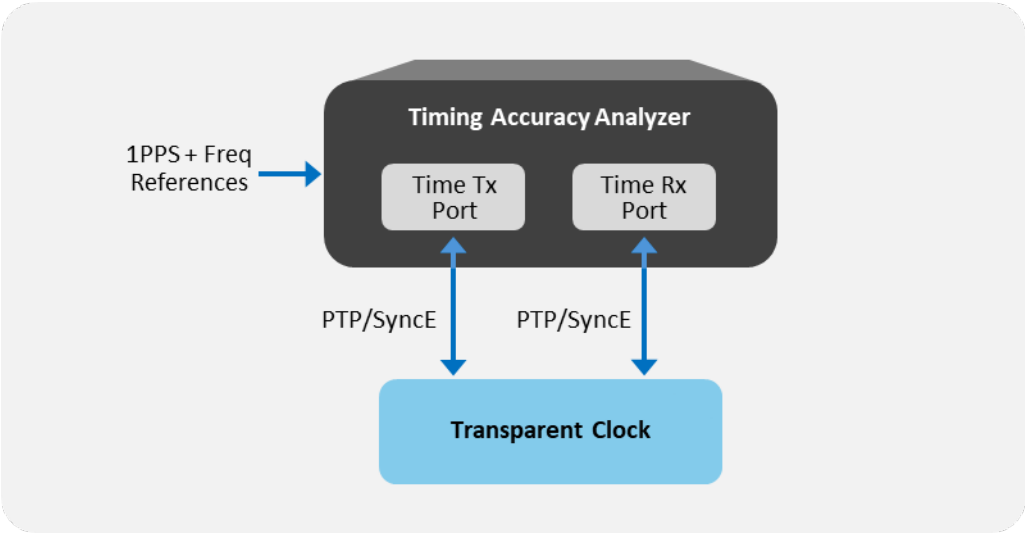


Figure 3-Transparent Clock Connections for Noise Tests

1. Connect the Analyzer PTP Time Transmitter Port to the TC upstream Port
2. Connect the Analyzer PTP Time Receiver port to the TC downstream Port
3. Connect external references to the Analyzer Reference inputs

Refer to Analyzer Manual for detailed instructions on set-up and connections

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

7. Noise Generation Test

7.1 Time Receiver and Boundary Clocks

Description:

The noise generation of a Time Receiver or Boundary clock represents the amount of noise produced at the output of said clock when there is an ideal input reference packet timing signal.

Under normal, locked operating conditions, the time output of the clock should be accurate to within the maximum absolute time error (TE) (max|TE|). This value includes all the noise components, i.e., the constant time error (cTE) and the dynamic time error (dTE) noise generation.

It may be desirable to consider results at both constant temperature and with temperature effects included, depending upon the intended end use environment.

Test Outline:
The Time Transmitter in the Time Analyzer generates PTP traffic with no impairments based on the external references.

This traffic is sent to the DUT, which responds with whichever delay request mechanism is in use.

The DUT recovers time and outputs some combination of 1pps, frequency and Time of Day signals.

The Analyzer captures these and compares them against the references, recording data which can be analyzed, either in real time or offline.

In the case of a Boundary clock, the PTP event traffic on the BC Time Transmitter port may also be captured and analyzed to determine its accuracy.

Things to Consider:
PTP Profile – which may include Ethernet encapsulation, packet rates, delay type, message contents, etc.

Length of test – how long should it be run for?
When testing at constant temperature G.8273.2 recommends testing for 1,000s.
When including temperature effects, the recommended test time is increased to 10,000s.

Test Limits – These will depend upon the end use environment. G.8273.2 may provide some guidance.

Procedure:
ITU-T Standard G.8273.2 specifies that the test should be conducted with PTP and SyncE active. If SyncE is not being used, then this requirement can be ignored.

There are no impairments required for this test.

Refer to the test equipment vendor's Analyzer manual for procedure to run Noise Generation Test

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Data and Results:

Refer to Analyzer manual to view the Data and Results

For information purposes, the G.8273.2 test limits are shown in tables below, with some notes from that standard.

The specifications are considered as an overall maximum absolute time error, which is split into three components – a constant time error contribution and low and high pass filtered dynamic time error contributions – each with their own limits.

Note - to support different performance requirements at the end application, using different network topologies and technologies, the maximum absolute time error, the constant time error and dTE noise generation requirements for BCs and Time Receivers are divided into four classes: Class A, Class B, Class C, and Class D.

At the precision time protocol (PTP) and 1 pulse per second (PPS) outputs, the maximum absolute time error (max|TE|) for Boundary Clocks and Time Receiver clock classes is shown in Table 1. This includes all time error components (unfiltered). The values in Table 1 are valid for 1 PPS interfaces and for 1GbE, 10GbE, 25GbE, 40GbE and 100GbE interfaces. Values for other interfaces are for further study.

BC/Time Receiver Class	Maximum Absolute Time Error – max|TE| ns
A	100 ns
B	70 ns
C	30 ns
D	For Further Study

Table 1 – G.8273.2 Max Time Error Limits.

NOTE – The values in Table 1, 3, 4, 5, and 6 are valid for 1 PPS interfaces and for 1GbE, 10GbE, 25GbE, 40GbE, 50GbE, 100GbE, 200GbE, 400GbE interfaces and 100GFlexE PHY. Values for other interfaces are for further study.

For Class D devices, the maximum time error measured through a first-order low-pass filter with a bandwidth of 0.1 Hz, max|TE_L|, is shown in Table 2.

BC/Time Receiver Class	Maximum absolute time error – max|TE_L| (ns)
D	5 ns

Table 2 – G.8273.2 Maximum absolute time error low-pass filtered (max|TE_L|).

NOTE – The detailed list of interfaces relevant to Table 2 is for further study.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

For the purpose of testing against the limits in Table 3, an estimate of constant time error should be obtained by averaging the time error sequence over 1000 s.

BC/Time Receiver Class	Permissible range of constant time error – cTE(ns)
A	±50
B	±20
C	±10
D	For Further Study

Table 3 G.8273.2 Permissible Range of Constant Time Error.

BC/Time Receiver Class	MTIE limit [ns]	Observation interval τ [s]
A	40	$m \leq \tau \leq 1\,000$ (Notes 1)
B	40	$m \leq \tau \leq 1\,000$ (Notes 1)
C	10	$m \leq \tau \leq 1\,000$ (Notes 1)
D	For further study	For further study
NOTE 1 – The minimum τ value *m* is determined by packet rate of 16 packet per second (*m*=1/16) or 1 PPS signal (*m*=1).		

Table 4 - Dynamic time error low-pass filtered noise generation (MTIE) for BC/Time Receiver with constant temperature (within ±1 K).

BC/Time Receiver Class	TDEV limit [ns]	Observation interval τ [s]
A	4	$m < \tau \leq 1\,000$ (Notes 1)
B	4	$m < \tau \leq 1\,000$ (Notes 1)
C	2	$m < \tau \leq 1\,000$ (Notes 1)
D	For further study	For further study
NOTE 1 – The minimum τ value *m* is determined by packet rate of 16 packet per second (*m*=1/16) or 1 PPS signal (*m*=1)		

Table 5 - Dynamic time error low-pass filtered noise generation (TDEV) for BC/Time Receiver with constant temperature (within ±1K).

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

BC/Time Receiver Class	MTIE limit [ns]	Observation interval τ [s]
A	40	$m \leq \tau \leq 10\ 000$ (Notes 1)
B	40	$m \leq \tau \leq 10\ 000$ (Notes 1)
C	10	$m \leq \tau \leq 10\ 000$ (Notes 1)
D	For further study	For further study
NOTE 1 – The minimum τ value m is determined by packet rate of 16 packet per second (m=1/16) or 1 PPS signal (m=1).		

Table 6 - Dynamic time error low-pass filtered noise generation (MTIE) for BC/Time Receiver with variable temperature.

For a BC or Time Receiver Clock of Class A or Class B operating in a locked mode synchronized to both a noise-free time reference at the PTP input and a noise-free frequency reference at the physical layer frequency input, the peak-to-peak time error at the output interfaces, measured over a 1,000 second measurement interval, with a first-order high-pass filter of 0.1 Hz must be less than 70 ns.

For class C and D devices, the dynamic time error high-pass filtered noise generation (dTEh) is for further study.

7.2 Transparent Clocks

Description:

TCs can introduce both constant time error (cTE) if they have an asymmetry error in the measurement and dynamic time error (dTE) if they have a variable accuracy error.

The noise generation of a TC represents the amount of noise produced at the output of the TC when there is an ideal input reference packet timing signal.

Under normal operating conditions, the time output of the TC should be accurate to within the maximum absolute time error (TE) (max|TE|). This value includes all the noise components, i.e., the cTE and the dTE noise generation.

Test Outline:
The Time Transmitter in the Time Analyzer generates PTP traffic with no impairments based on the external references for both the forward and the reverse direction.

This traffic is sent to the DUT, which updates the correction field in the relevant messages (sync or follow up and (peer) delay request or (peer) delay response) and transmits the modified messages back to the analyzer.

The Analyzer captures these and compares the actual residence time with the device measured residence time in the correction fields, recording data which can be analyzed in real time or offline.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Things to Consider:

PTP Profile – which may include Ethernet encapsulation, packet rates, delay type, message contents etc.

Length of test – how long should it be run for?

When testing at constant temperature G.8273.3 recommends testing for 1,000s.

When including temperature effects, the recommended test time is increased to 10,000s.

Test Limits – These will depend upon the end use environment. G.8273.3 may provide some guidance. Examples from G.8273.3 are included in this document.

Procedure:

ITU-T Standard G.8273.3, specifies that the test should be conducted with PTP and SyncE active. If SyncE is not being used, then this requirement can be ignored.

There are no impairments required for this test.

Refer to the test equipment vendor's Analyzer manual for the procedure to run Noise Generation Test

Data and Results:

Refer to Analyzer manual to view the Data and Results

G.8273.3 specifies different classes of devices for different performance requirements. For information purposes, the G.8273.3 test limits are shown in tables below, with some notes from that standard.

The applicable limits for data centers are for further study.

Maximum absolute time error generation

At the precision time protocol (PTP) output, the maximum absolute time error (max|TE|) for TC is shown in the table below. This includes all time error components (unfiltered).

Maximum absolute time error TC class	Maximum absolute time error – max|TE| (ns)
A	100
B	70
C	For further study

The specifications are considered as an overall maximum absolute time error, which is split into three components – a constant time error contribution and low and high pass filtered dynamic time error contributions – each with their own limits.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Constant time error generation (cTE)
At the PTP outputs, the cTE generation for class A and class B as defined in G.8273.3 is shown in the table below.

TC permissible range of cTE TC class	Permissible range of cTE (ns)
A	±50
B	±20
C	±10

Dynamic time error generation (dTE)
G8273.3 splits dTE into two components, high and low frequency. For information purposes the limits from that standard are shown in the tables below for both constant and variable temperatures.

Dynamic time error noise generation (MTIE) for TC with constant temperature TC class	MTIE limit (ns)	Observation interval τ (s)
A	40	$m < \tau \leq 1000$ (Note 1), (Note 2)
B	40	$m < \tau \leq 1000$ (Note 1), (Note 2)
C	10	$m < \tau \leq 1000$ (Note 1), (Note 2)
NOTE 1 – The minimum τ value *m* is determined by a packet rate of 16 packet per second (*m*=1/16). NOTE 2 – The values in this table are valid for 1GbE, 10GbE, 25GbE, 40GbE and 100GbE interfaces. Values for other interfaces are for further study.		

Dynamic time error noise generation (MTIE) for TC with variable temperature TC class	MTIE limit (ns)	Observation interval τ (s)
A	40	$m < \tau \leq 10000$ (Note 1), (Note 2)
B	40	$m < \tau \leq 10000$ (Note 1), (Note 2)
C	For further study	$m < \tau \leq 10000$ (Note 1), (Note 2)
NOTE 1 – The minimum τ value *m* is determined by a packet rate of 16 packet per second (*m*=1/16). NOTE 2 – The values in this table are valid for 1GbE, 10GbE, 25GbE, 40GbE and 100GbE interfaces. Values for other interfaces are for further study.		

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

8. Noise Tolerance Test

8.1 Time Receiver and Boundary Clocks

Description:

The noise tolerance of a Time Receiver or Boundary clock indicates the minimum dynamic time error level at the input of the clock that should be accommodated while:

- not causing any alarms
- not causing the clock to switch reference
- not causing the clock to go into holdover

Note – There is no requirement related to cTE tolerance.

Test Outline:

The Time Transmitter in the Analyzer generates PTP traffic based on the external references.

Some form of time impairment is applied, for example by delaying packets relative to each other or by adjusting the timestamps in the packet.

Typically, the impairment takes the form of a sine wave or series of sine waves with fixed frequencies and amplitudes.

This traffic is sent to the DUT, which responds with whatever delay request mechanism is in use.

The DUT recovers time and outputs a 1pps, frequency Time of Day signals.

The Analyzer captures these and compares them against the references, recording data which can be analyzed, either in real time or later.

In the case of a Boundary clock, the PTP traffic on the BC Time Transmitter port can also be captured and analyzed.

Things to Consider:

PTP Profile – which may include Ethernet encapsulation, packet rates, delay type, message contents etc.

Length of test – how long should it be run for?

Choice of impairment waveforms.

Minimum requirement for DUT noise tolerance.

Procedure:
ITU-T Standard G.8273.2, specifies that the test should be conducted with PTP and SyncE active.

If SyncE is not being used, then this requirement can be ignored.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Refer to the test equipment vendor's Analyzer manual for procedure to run Noise Tolerance Test

Data and Results:

Refer to Analyzer manual to view the Data and Results

Note - For these particular tests, it may be necessary to monitor the device directly for alarms or to detect that it has gone into holdover.

A BC or Time Receiver Clock of class A or B for use in the full timing support profile should be capable of tolerating the following levels of dTE and phase wander simultaneously:

– dTE according to [ITU-T G.8271.1] network limit, clause 7.3 at the PTP input;
– wander tolerance according to [ITU-T G.8262], clause 9.1 at the SyncE input;
– wander tolerance according to [ITU-T G.813], clause 8.1 at the SDH input.

The noise tolerance for classes C and D is for further study.

8.2 Transparent Clocks

The noise tolerance of a TC indicates the minimum dTE level at the input of the clock that should be accommodated while:

– not causing any alarms.

G.8273.3 does not specify noise tolerance for the packet input, only the frequency input, which is not required in this case.

Should it be desired to carry out a noise tolerance test on the packet input, the analyzer should be used to add an impairment to the TC upstream port. This may take the form of a sine wave applied to the TA packet output with an increasing amplitude and increasing frequency.

The TC management port should be monitored for alarms.

The TA can be used to analyse the performance of the TC to determine whether its accuracy is maintained during the test.

The proposed amplitude and frequency ranges are for further study.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

9. Noise Transfer Test

9.1 Time Receiver and Boundary Clocks

Description:

This test aims to confirm the effect of any filtering that is applied to the input to reduce the amount of noise transferred to the output.

This test only considers the Dynamic Time Error – dTE. There is no requirement for cTE transfer.

The noise transfer tests can look at PTP to PTP transfer (as in a boundary clock).

They can also look at noise transfer between syncE and PTP/1pps and from PTP to SyncE in the case of a boundary clock. (Check these statements).

G.8273.2 specifies the minimum and maximum bandwidths of the devices.

It also warns against certain test frequency combinations to avoid sub-Nyquist and other effects. The specific notes are captured below.

NOTE 1 – For purposes of measuring the noise transfer, the impact of the test method may be critical. For example, it is known that some signal artefacts (known as sub-Nyquist artefacts) may be present due to improper test frequency selection. In particular, when using direct measurement methods or when measuring the noise transfer of a nonlinear filter, test signal frequencies that are equal to (m/n) multiplied by the Nyquist frequency, where (m/n) is a reduced fraction and m and n are small integers (e.g., less than 10) should be avoided. For instance, for a Nyquist frequency of 0.5Hz, examples of frequencies that should be avoided are 0.1 Hz (m=1, n=5), 0.25 Hz (m=1, n=2), 0.3 Hz (m=3, n=5), 0.5 Hz (m=1, n=1), 0.7 Hz (m=7, n=5), 1Hz (m=2, n=1), 2Hz (m=4, n=1), etc. and frequencies very close to these frequencies. Other mathematical processing methods may be less restricted with the choice of frequencies used. However, frequencies of the type (m,1) should be avoided as they cannot be measured. Details on specific methods are for further study.

NOTE 2 – At all permissible noise input levels, the gain peaking from PTP to PTP, or from physical layer frequency to PTP is far lower than the permitted noise generation of the clock at the PTP and 1 PPS outputs. Therefore, it may be difficult to verify the gain peaking at either the PTP or 1 PPS outputs.

Test Outline:

The analyzer generates a PTP traffic stream along with SyncE and ESMC if present.

The PTP traffic or syncE waveform is impaired with predefined noise – typically in the form of one or more sine waves in a manner similar to the noise tolerance tests.

The output is measured and compared to the input.

Procedure:

Refer to Analyzer manual for procedure to run Noise Transfer Test

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Data and Results:

Refer to Analyzer manual to view the Data and Results

Things to Consider:

PTP Profile – which may include Ethernet encapsulation, packet rates, delay type, message contents etc.

Length of test – how long should it be run for?

Filter characteristics being tested.

9.2 Transparent Clocks

PTP to PTP noise transfer

There is no filtering of the PTP signal required in the TC. The TC is not permitted to amplify input time error on its output.

NOTE – The case of syntonization provided by PTP is for further study.

The TA Time Transmitter may add impairments such as a sine wave of fixed frequency and amplitude within the tolerance limits of the TC. The measured signal on the TA should be identical to the transmitted signal once the CF values have been taken into account.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

10. Holdover Test (applicable to Time Receiver and Boundary Clocks)

Description:
When the frequency and/or PTP inputs are lost, the device should go into holdover where it attempts to use its internal oscillator to maintain the time and frequency output within certain limits for a specified period.

This test aims to determine whether those limits are maintained.

If SyncE is in use, then the DUT should switch to using this as the frequency reference in the absence of PTP.

Test Outline
The analyzer is used to generate PTP traffic and syncE. At some point the input(s) is/are removed and the effect on the DUT output is recorded.

Procedure:

Refer to Analyzer manual for procedure to run Holdover Tests

Data and Results:

Refer to Analyzer manual to view the Data and Results

It may also be necessary to refer to the DUT itself.

Things to Consider:
PTP Profile – which may include Ethernet encapsulation, packet rates, delay type, message contents etc.

Length of test – how long should it be run for?

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

11. Connecting TA Analyzer with a Clock for Transient Tests

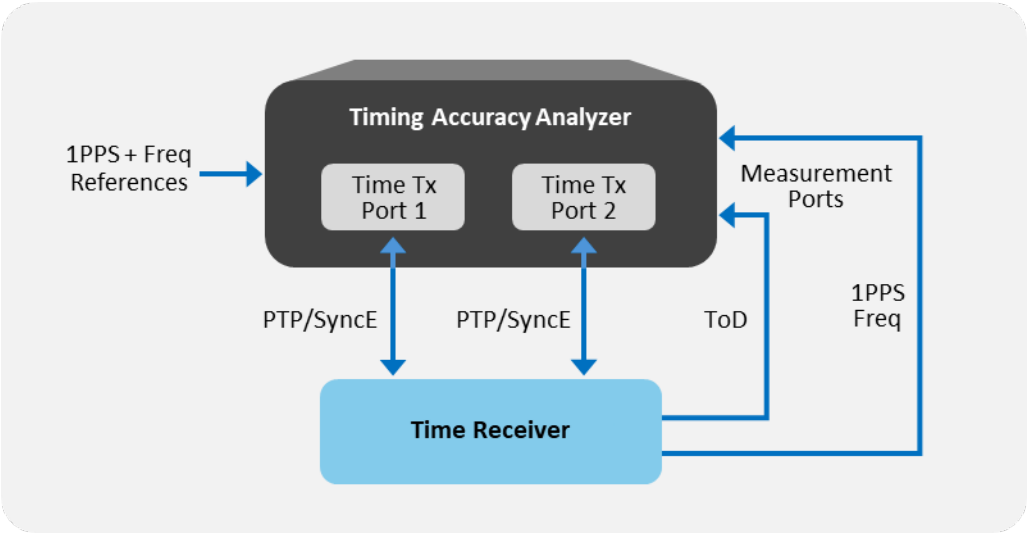


Figure 4-Test set up for performing transient response testing.

1. Connect the Analyzer PTP Time Transmitter Port 1 to the Time Receiver Port 1
2. Connect the Analyzer PTP Time Transmitter Port 2 to the Time Receiver Port 2
3. Connect external references to Analyzer Reference inputs
4. Connect the Time Receiver 1pps output to the Analyzer 1pps Input Port
5. Connect the Time Receiver Frequency output to the Analyzer Frequency Input Port

Refer to Analyzer Manual for detailed instructions on set-up and connections

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

12. Transient Tests

12.1 Time Receiver and Boundary Clocks

Description:

The purpose of these tests is to verify the transient output response of the DUT when the input undergoes some sort of step change – for example a network rearrangement due to switching between grandmasters.

The device should react to the loss of signal within a specified time and regain lock, again within a specified time.

There are a few possible scenarios depending on whether Sync-E is in use.

Note – Sync-E is specified in ITU standard G.8262.1.

The following cases are taken from G.8273.2.

PTP output and 1PPS output transient response due to rearrangement of physical layer frequency transport and PTP network

The transient response of the clock due to a simultaneous or nearly coincident rearrangement of both the PTP network and the physical layer frequency transport.

Note – G.8273.2 states that this is for further study.

PTP output and 1PPS output transient response due to rearrangement of PTP network

Note – G.8273.2 states that this is for further study.

PTP output and 1PPS output transient response due to rearrangement of physical layer frequency transport

The physical layer frequency to PTP and physical layer frequency to 1 PPS transient response due to a rearrangement of the physical layer frequency transport (with noise-free PTP) is specified in G.8273.2 Annex B for clock classes A and B, and in Annex C for clock class C.

The physical layer frequency to PTP and physical layer frequency to 1 PPS transient response due to a rearrangement of the physical layer frequency transport is for further study for clock class D.

PTP output and 1PPS output transient response due to long term rearrangement of physical layer frequency transport

At the precision time protocol (PTP) and 1 pulse per second (PPS) outputs, over any period of S > 15 s, the maximum absolute time error (max|TE|), excluding any constant time error (cTE), is constrained to below 58 ns for T-BC/T-TSC class C with

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

constant temperature (within ±1K) or variable temperature. The requirement is evaluated without a measurement filter on the TE samples. This requirement is for further study for T-BC classes A, B, and D.

Test Outline:

A PTP transient can be generated by changing the contents of one or both announce messages, to trigger a change based on the Best Time Transmitter Clock Algorithm (BTCA).

In the case where sync-E is in use, a sync-E transient may be generated by the Analyzer, along with a change in the ESMC message.

Further Details are provided in G.8273 Appendix III.

Procedure:

Refer to Analyzer manual for procedure to run Transient Response Tests

Data and Results:

Refer to Analyzer manual to view the Data and Results

For this test it may also be necessary to consult the DUT directly.

Things to Consider:

PTP Profile – which may include Ethernet encapsulation, packet rates, delay type, message contents etc.

Types of events that may cause transients.

12.2 Transparent Clocks

At the moment, no requirements on transients have been specified by G.8273.3.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

13. Conclusion

Verification of the performance of clocks is key to guarantee end-to-end performance in a synchronization distribution chain. The purpose of this document is to provide an example test guide to verify the performance of clocks that can be used in a datacenter application.

The requirements are based on Telecom applications (i.e., referring to ITU-T recommendations), that can be considered as consistent with some of the most stringent classes of requirements applicable also in datacenters.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

14. References

ITU-T G.8273.2 Timing characteristics of telecom boundary clocks and telecom time slave clocks for use with full timing support from the network

ITU-T G.8273.3 Timing characteristics of telecom transparent clocks for use with full timing support from the network

ITU-T G.8273 Framework of phase and time clocks

ITU-T G.8262.1 Timing characteristics of enhanced synchronous equipment slave clock

IEEE Std 1588-2008 and IEEE 1588-2019 - IEEE Standards for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

15. License

15.1 Creative Commons

OCP encourages participants to share their proposals, specifications and designs with the community. This is to promote openness and encourage continuous and open feedback. It is important to remember that by providing feedback for any such documents, whether in written or verbal form, that the contributor or the contributor's organization grants OCP and its members irrevocable right to use this feedback for any purpose without any further obligation.

It is acknowledged that any such documentation and any ancillary materials that are provided to OCP in connection with this document, including without limitation any white papers, articles, photographs, studies, diagrams, contact information (together, "Materials") are made available under the Creative Commons Attribution-ShareAlike 4.0 International License found here: https://creativecommons.org/licenses/by-sa/4.0/, or any later version, and without limiting the foregoing, OCP may make the Materials available under such terms.

As a contributor to this document, all members represent that they have the authority to grant the rights and licenses herein. They further represent and warrant that the Materials do not and will not violate the copyrights or misappropriate the trade secret rights of any third party, including without limitation rights in intellectual property. The contributor(s) also represent that, to the extent the Materials include materials protected by copyright or trade secret rights that are owned or created by any third-party, they have obtained permission for its use consistent with the foregoing. They will provide OCP evidence of such permission upon OCP's request. This document and any "Materials" are published on the respective project's wiki page and are open to the public in accordance with OCP's Bylaws and IP Policy. This can be found at http://www.opencompute.org/participate/legal-documents/. If you have any questions, please contact OCP.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

16. About Open Compute Foundation

The Open Compute Project (OCP) is a collaborative Community of hyperscale data center operators, telecom, colocation providers and enterprise IT users, working with the product and solution vendor ecosystem to develop open innovations deployable from the cloud to the edge. The OCP Foundation is responsible for fostering and serving the OCP Community to meet the market and shape the future, taking hyperscale-led innovations to everyone. Meeting the market is accomplished through addressing challenging market obstacles with open specifications, designs and emerging market programs that showcase OCP-recognized IT equipment and data center facility best practices. Shaping the future includes investing in strategic initiatives and programs that prepare the IT ecosystem for major technology changes, such as AI & ML, optics, advanced cooling techniques, composable memory and silicon. OCP Community-developed open innovations strive to benefit all, optimized through the lens of impact, efficiency, scale and sustainability. Learn more at www.opencompute.org.

Date: February 2026

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.