G.8273.2 T-TSC Conformance Test

Testing T-TSCs up to Class-D performance requirements as per ITU-T G.8273.2 using Paragon-neo

- Noise Generation
- Noise Tolerance
- Noise Transfer
- Transient Response
- Holdover Performance

The accuracy of T-TSCs is essential to the successful roll-out of 5G as well as being integral for LTE-A. To meet requirements including G.8273.2 compliance limits up to Class-D for 5G Enhanced Time, T-TSCs must meet very stringent Maximum Time Error limits of as low as 5 nanoseconds. This ensures that the highest number of nodes can be deployed within the network's Time Error budget.

This Test Guide shows how the Calnex Paragon-neo can be used to test T-TSC compliance as per G.8273.2 and provides procedures to measure noise generation, time noise tolerance and transfer, packet layer transient response and holdover performance.

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Contents

1   Hardware and Software Required

Paragon-neo

Opt. NEO-1G-10G*	1/10GbE interface support (if the Device Under Test (DUT) has 1G and/or 10G interfaces)
Opt. NEO-25G*	25GbE interface support (if the DUT has 25G interfaces)
Opt. NEO-40G*	40GbE interface support (if the DUT has 40G interfaces)
Opt. NEO-50G*	50GbE interface support (if the DUT has 50G interfaces)
Opt. NEO-100G*	100GbE interface support (if the DUT has 100G interfaces)
Opt. NEO-A-PAM4-50G	PAM4 50GbE interface support (if the DUT has PAM4 50G interfaces)
Opt. NEO-A-PAM4-100G	PAM4 100GbE interface support (if the DUT has PAM4 100G interfaces)
Opt. NEO-A-PAM4-200G	PAM4 200GbE interface support (if the DUT has PAM4 200G interfaces)
Opt. NEO-A-PAM4-400G	PAM4 400GbE interface support (if the DUT has PAM4 400G interfaces)
Opt. NEO-PTP-G.8275.1*	Emulation of G.8275.1 PTP timeTransmitter and timeReceiver devices, with associated Time Error Impairment and measurement capability
Opt. NEO-SyncE-Wander*	SyncE Wander and ESMC
Opt. NEO-Background-Traffic	Background Traffic Generation (to test using ITU-T G.8273 methodologies)

*Also available on PAM4-enabled Paragon-neo A units. Please replace the *NEO-* with *NEO-A* for the PAM4 version.

Paragon-neo software version:	11.00.xx or later
Paragon-neo A software version	11.00.xx or later

Accessories

- Optical Transceivers as required.
- Cables as required.

Document References

- IEEE Std 1588TM - 2008 IEEE Standard for a Precision Clock Synchronisation Protocol for Networked Measurement and Control Systems
- IEEE Std 1588TM - 2019 IEEE Standard for a Precision Clock Synchronisation Protocol for Networked Measurement and Control Systems
- Recommendation ITU-T G.8275.1 Precision time protocol telecom profile for phase/time synchronization with full timing support from the network
- Recommendation ITU-T G.8273.2 Timing Characteristics of Telecom Boundary Clocks
- Recommendation ITU-T G.8262 Timing characteristics of synchronous equipment slave clock
- Recommendation ITU-T G.8262.1 Timing characteristics of enhanced synchronous equipment slave clock
- Recommendation ITU-T G.8273 Framework of phase and time clocks
- Calnex Technical Note: Cabling Considerations (CX5009), download here
- Calnex PFV Getting Started Guide, download here
- Calnex Paragon-neo Getting Started Guide. The guide is provided with Paragon-neo document set or download here

2   Document Information

It should be noted that the tests in the guide are timing performance tests and focus on the quality of the timing output from the device-under-test as defined in the relevant standards and recommendations.

However, during product development or qualification other aspects of device behavior and performance may be of interest. Such aspects could include:

- Device warm-up time and duration required to achieve optimal performance with both ideal and non-ideal reference inputs.
- Performance under various input reference impairment profiles, failure modes and the subsequent recovery times.
- Device performance changes depending on the order, concurrency, and duration of multiple fail events.
- Type and quality of events reported by the device via the management interfaces.
- Accuracy of on-device timing performance monitoring and reporting functions.

In the case of the above being required, the test procedures in this document can be used as a basis for you to design your own tests to study those aspects.

The Calnex Sentinel and Paragon-x products can be used to capture real-life network performance and can be imported into Paragon-neo as impairment profiles.

3   Connecting Paragon-neo to the Device-Under-Test (DUT)

The physical connections between Paragon-neo and the DUT are detailed below.

Information regarding the Paragon-neo front panel connections and interface are detailed in the **Calnex Paragon-neo Getting Started Guide**. This document is provided as part of the Paragon-neo on-instrument document set, accessible from the **Help** menu in the top right of the Paragon-neo Graphical User Interface (GUI).

3.1   Connections to Device Under Test
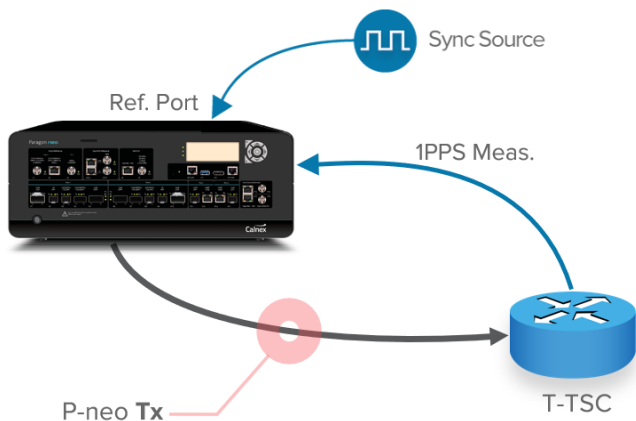
1. Connect Port 1 (timeTransmitter side of Paragon-neo) to the T-TSC timeReceiver side.
2. Connect the 1PPS or 1PPS+ToD output from the T-TSC to the Paragon-neo 1PPS Measurement port.
3. If desired, connect an external reference, e.g. 10MHz, to the Paragon-neo Reference input.

4   Setting up the Paragon-neo for G.8273.2 Conformance Tests

The following steps are required to set up the Paragon-neo prior to performing G.8273.2 Conformance tests:

4.1 Connection to Paragon-neo

4.2 Configuration of Physical Connections

4.3 Test Configuration

4.4 Device Connection Settings

4.1   Connection to Paragon-neo

1.   Verify the physical connections have been completed as described in Section 3 for the relevant test type.

2.   From a PC, open a browser and enter the IP address of the Paragon-neo unit. See the Paragon-neo Getting Started Guide for more details.

4.2   Configuration of Physical Connections

1.   Select **Setup Ports** from the onscreen display and select those reference and test ports to be used.

2.   If required, enter **Threshold** and **Termination** information for 1PPS signals. Voltage thresholds should be set to one decimal place to ensure best accuracy of test and measurement.

4.3   Test Configuration

1.   Select **Run Apps,** then the **Conformance Test** preset**:**
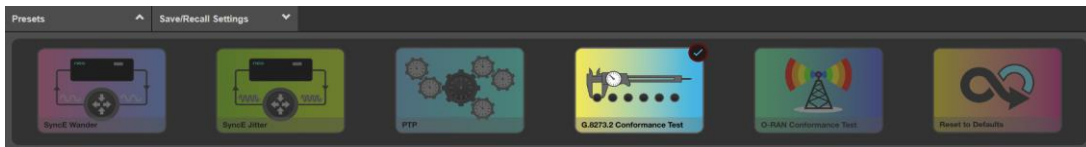
## 4.4 Device Connection Settings

It is assumed that a G.8275.1 profile will be used in testing per the G.8273.2 standard, as a result testing will be carried out using L2 encapsulation in Multicast mode. The Paragon-neo PTP Emulation can be configured to use other profiles, e.g. Unicast UDP/IPV4 etc., however, it should be noted that these profiles will not conform to the G.8273.2 standard. As per the requirements of G.8275.1, SyncE should also be used.

1. In the **PTP Emulation** app, select **timeReceiver** as the **Test Mode.**

2. In the **PTP Emulation** app, select **G8275.1 Phase Profile** as the **PTP Profile** then select the required PTP Standard (IEEE-1588 2008 or IEEE-1588 2019).

3. Select **Test Config** and make any necessary cable delay compensation settings in the **Test Configuration** page.

    Delay values are represented in nanoseconds and should be entered to one decimal place (i.e. *x.y*) for best results. For the coaxial cable, values of 4.5 to 5.1ns per meter are typical; this should be confirmed by datasheet or vendor. Once correct values have been entered, click **Apply**.
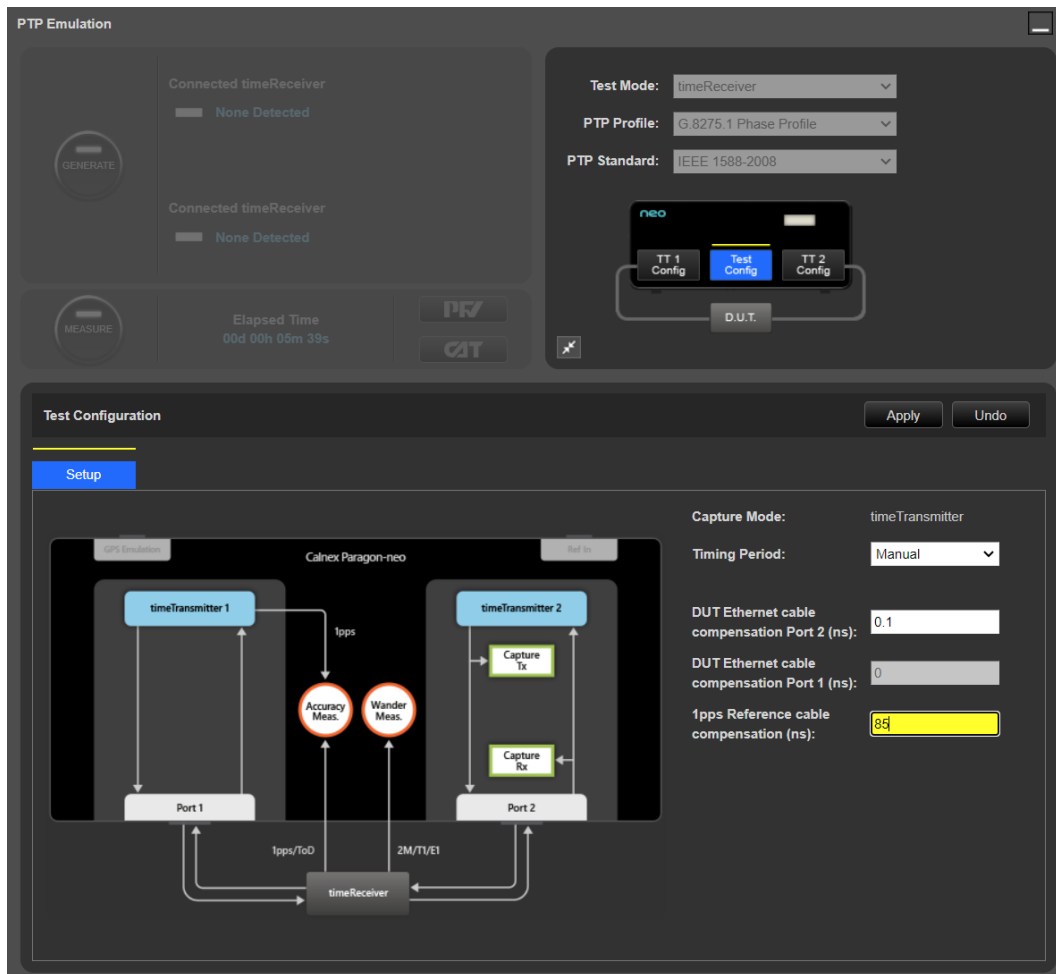
4. In the **1pps Time Error Measurement + Time of Day** app, enter the cable delay compensation value for the measurement cable.
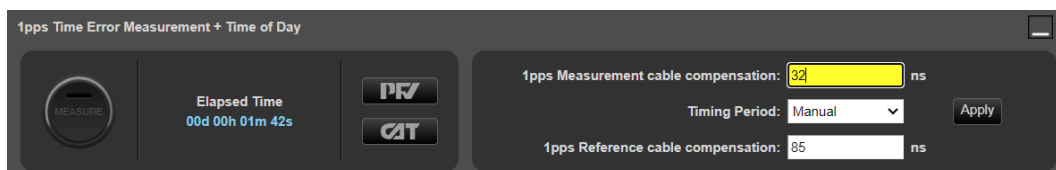

Further information to assist with entering cable delay values is provided in the **Quick Help** in the left-hand pane within the Paragon-neo GUI.
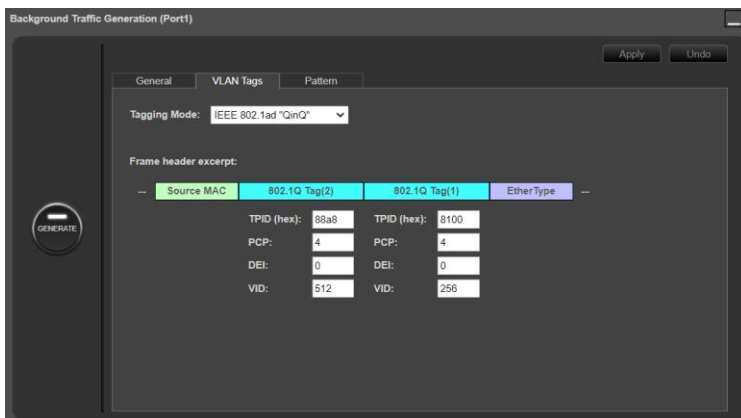
4.5 Background Traffic

The measurement methodologies specified in ITU-T G.8273 Annex B include a requirement for traffic generation to introduce suitable loading on the ports of the DUT that carry the timing packets.

The Paragon-neo Background Traffic Generation application provides the ability to test to the ITU-T G.8273 requirements by generating Ethernet or IP packets in addition to the PTP and ESMC packets on Port 1 and Port 2.
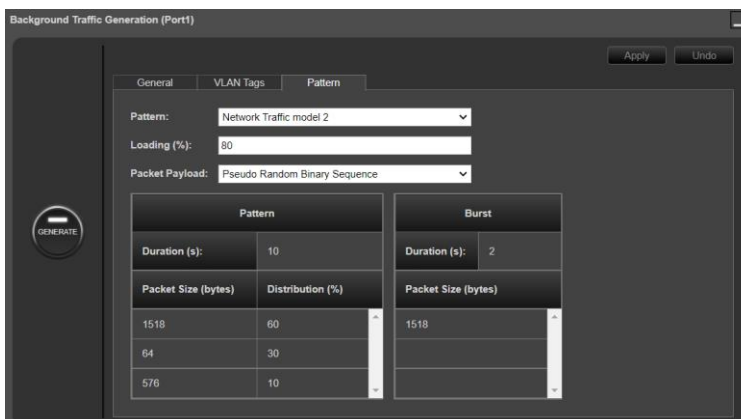
1. In the **Background Traffic Generation** app for the required Paragon-neo port, choose **General** and select the encapsulation, source and destination addresses for the generated traffic.
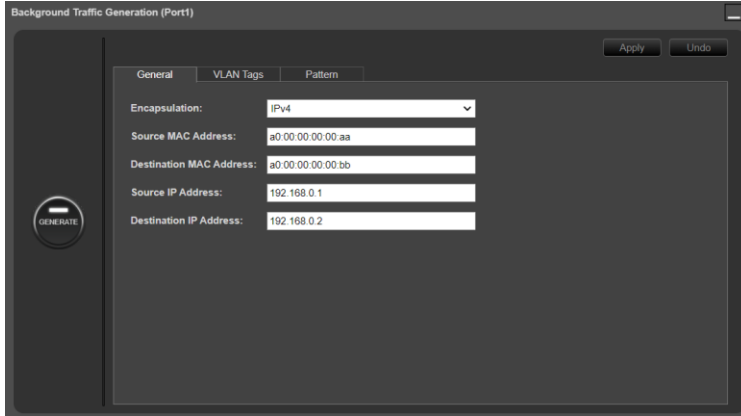
2. Select the **VLAN Tags** tab and if required, configure the VLAN parameters.

3. Select the **pattern** tab and configure the required parameters for the traffic pattern, loading and payload.

4. Clicking on **Generate** at any time begins the transmission of the background traffic.

5 Noise Generation – G.8273.2 Clause 7.1

Test Description

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

The noise generation is measured on the 1PPS output of the DUT using multiple metrics. The table below summarizes the metrics and limits that apply to the output performance of each class of clock as defined in ITU-T G.8273.2. Any differences in the specification to constant (within ±1K) or variable temperature conditions are detailed in the notes; if there is no note then the specification is identical for both temperature conditions.

| DUT Class	Max$|TE|$	Max$|TE_L|$	cTE [1]	dTE$_{LF}$ [2,3]	dTE$_{HF}$
Class A	≤ 100ns	-	≤ 50ns	40ns MTIE 4ns TDEV	≤ 70ns p-p
Class B	≤ 70ns	-	≤ 20ns	40ns MTIE 4ns TDEV	≤ 70ns p-p
Class C	≤ 30ns	-	≤ 10ns	10ns MTIE 2ns TDEV	≤ 30ns p-p
Class D	For Further Study	≤ 5ns	For Further Study	For Further Study	For Further Study

Notes:

1. Constant Time Error is measured under constant temperature conditions only.
2. MTIE dTE$_{LF}$ has different specification for the MTIE observation window (τ) for constant temperature (τ ≤ 1000s) and variable temperature (τ ≤ 10000s). The limit is the same for both, it is the size of the observation window that changes.
3. TDEV is specified for constant temperature conditions only.

Measurement Process

1. Confirm that the DUT is correctly connected to Paragon-neo and the settings within the **PTP emulation** app are appropriate for the current test scenario as described in Sections 3 and 4.

2. Configure the DUT test environment for either a constant or variable temperature test; guidelines for variable temperature testing are described in Appendix I of ITU-T G.8273.

   Note that the results analysis process is different depending on the temperature conditions of the test and is described in different sections below.

3. To test to the measurement methodology specified in ITU-T G.8273, ensure the **Background Traffic** app is configured as described in Section 4.5.

4. From the **Test:** drop-down menu, select **Noise Generation (Clause 7.1).**
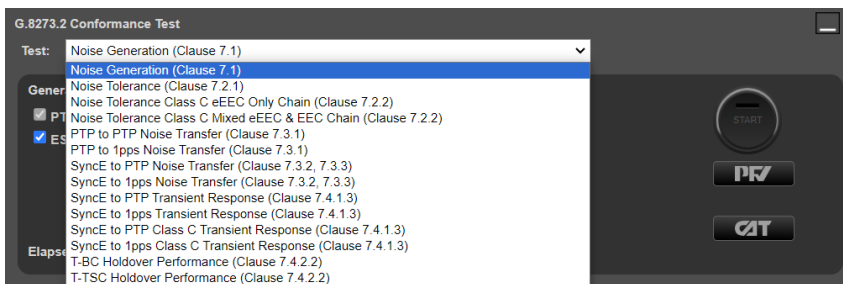
5. From the **Measurement** section of the **Conformance Test** app, check the **1pps Time Error** checkbox.
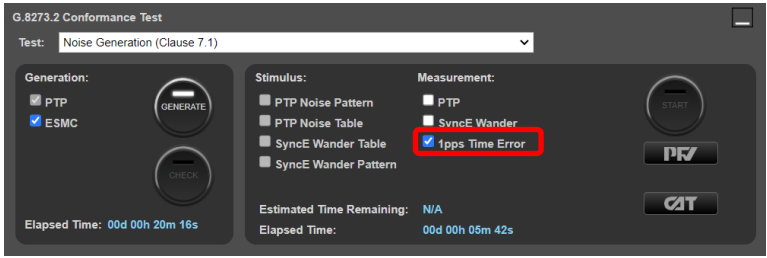

6. From the **Generation** section of the **Conformance Test** app, press **Generate**. This starts PTP and ESMC message generation allowing the DUT to stabilize.

    Pressing **Check** will run a simultaneous data capture after which you can open the CAT in a new tab to check current timing performance. In this case, you should wait for a **2WayTE measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.

7. Once the DUT is stable, in the **Stimulus/Measurement** section, press **Start** to run the Noise measurement.

    The recommended measurement duration is a minimum of 12,000s and this applies to a constant temperature or variable temperature test. Time Error results can either be viewed during capture or after capture has been stopped.
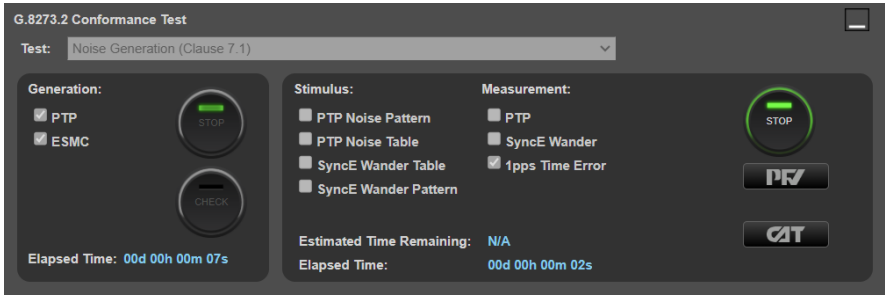
8. Select **CAT**. The Calnex Analysis Tool will open in a new browser tab displaying the default metrics.
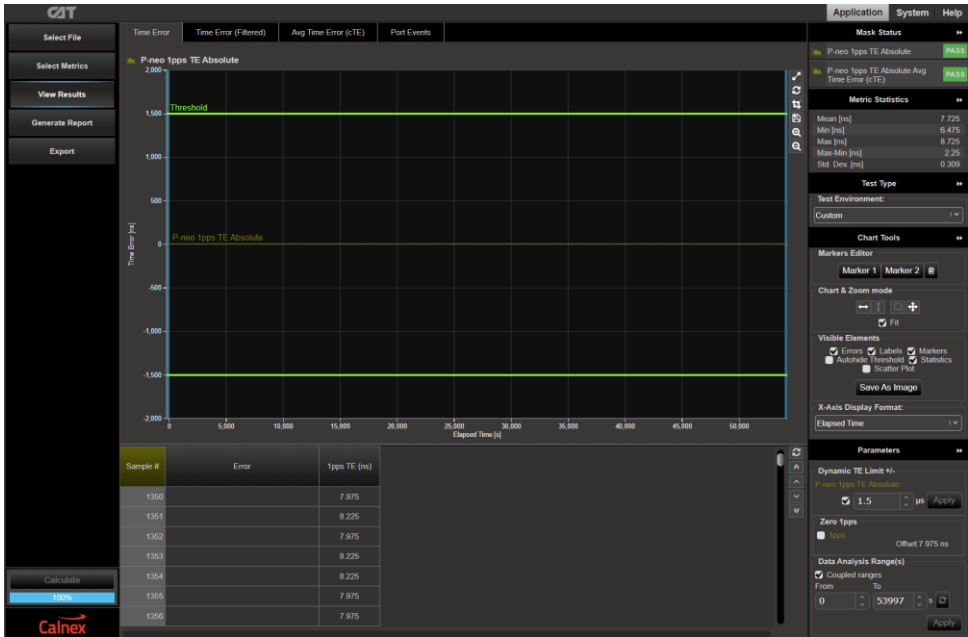

9. Follow the steps in the appropriate section (0 or 5.2) below depending on whether the test was under constant or variable temperature conditions. Additionally, options for further analysis are provided in section **Error! Reference source not found.**.

5.1 Constant Temperature Test Results analysis

The steps in this section describe how to analyze the results of a test made under constant temperature conditions.

1. In CAT, select the appropriate **Test Environment** for the DUT class and output type. Note that the metrics and masks applied by the **Test Environment** are for a constant temperature test. The settings for a variable temperature test are in the next section.
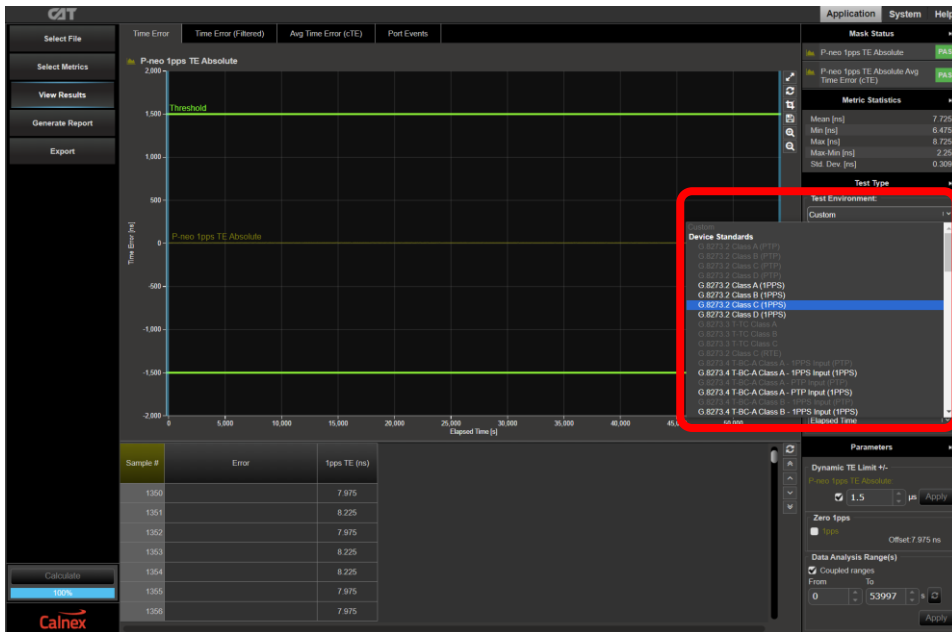
Navigate to the available metrics for the **Test Environment** by using the tabs at the top of the window.

2. The T-TSC performance meets requirements when the output is within the applied masks and thresholds. The Pass/Fail status is indicated in the **Mask Status** block in the top-right area of the CAT display.

5.2 Variable Temperature Test Results Analysis

The steps in this section apply to a test made under variable temperature conditions. Guidelines for variable temperature testing are described in Appendix I of ITU-T G.8273.
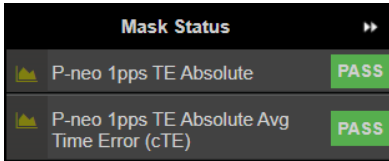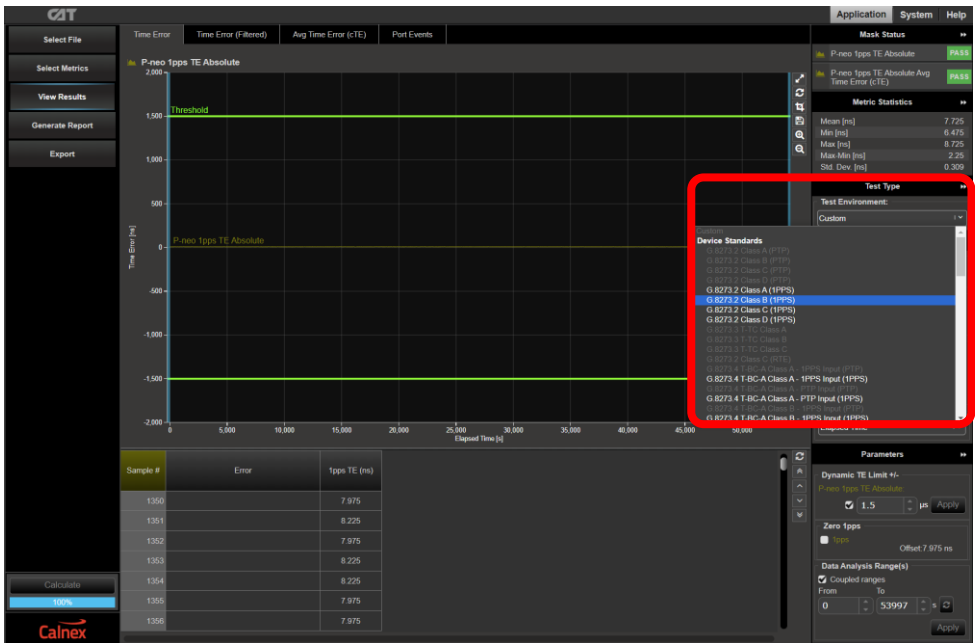
1. In CAT, select the appropriate **Test Environment** for the DUT class and output type. Note that the metrics and masks applied by the **Test Environment** are for a constant temperature test. The settings for a variable temperature are set by the steps below.


2. Click **Select Metrics** and uncheck the metrics for the **Avg Time Error (cTE)** and all the **TDEV** metric in the **Dynamic Time Error** section. The unchecked metrics will be removed from the measurement results.
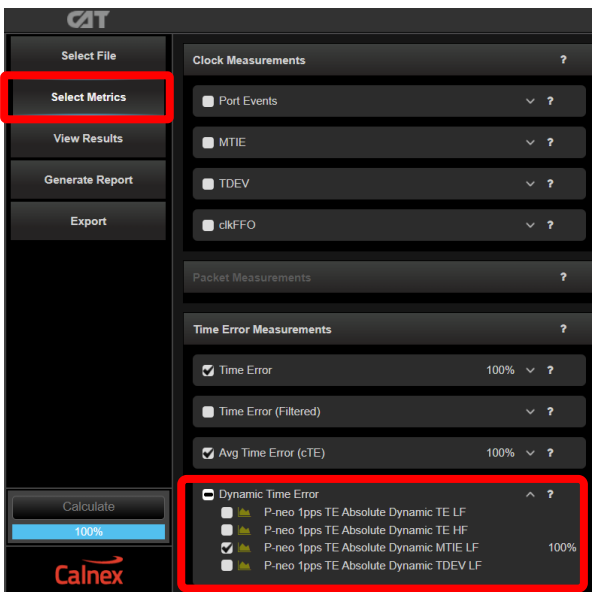
3. Select **View Results**, then navigate to the **Dynamic Time Error** tab and select the appropriate mask for the device class. The "...T-BC.." masks also apply to T-TSC devices.

Device Class	Dynamic MTIE LF Mask
Class A	G.8273.2 T-BC Class A Dynamic TE LF Var. Temp.
Class B	G.8273.2 T-BC Class B Dynamic TE LF Var. Temp.
Class C	G.8273.2 T-BC Class C Dynamic TE LF Var. Temp.
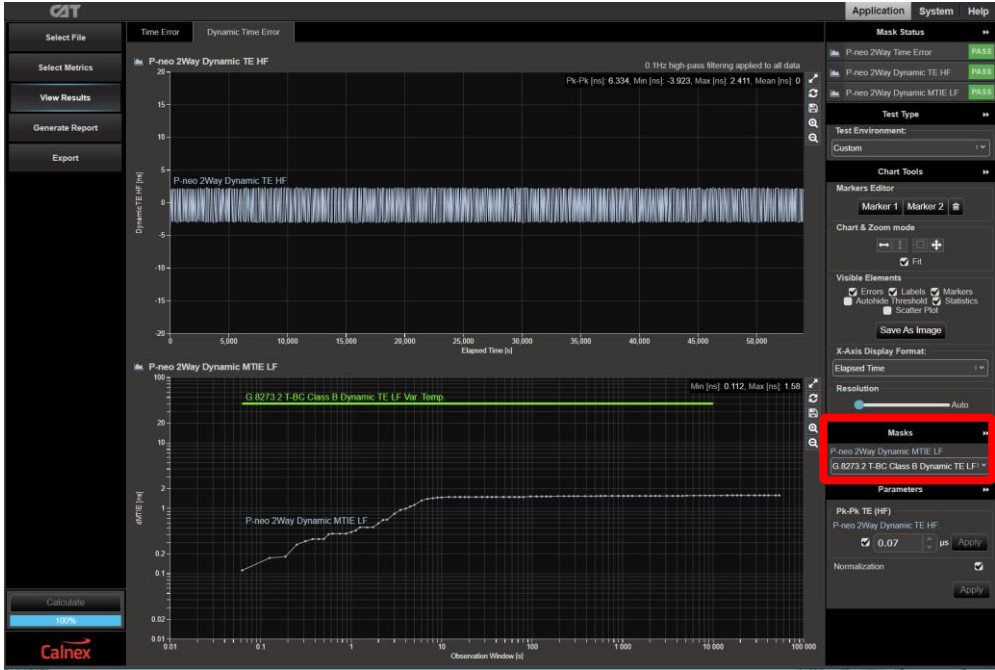
4. The T-TSC performance meets requirements when the output is within the applied masks and thresholds. The Pass/Fail status is indicated in the **Mask Status** block in the top-right area of the CAT display.

6 Noise Tolerance – G.8273.2 Clause 7.2

Test Description

This test checks whether the clock maintains normal operation in the presence of maximum PTP and SyncE noise.

There are no output performance requirements on the output of the T-TSC during a noise tolerance test. A clock is merely expected to work normally during a noise tolerance test.

The table below summarizes the noise tolerance requirements for each class of clock.

| DUT Class	PTP Input Noise	SyncE Input Wander
Class A & B	ITU-T G.8271.1 Network Limit clause 7.3	ITU-T G.8262 clause 9.1.1 (Opt. 1 Clock)
Class C	ITU-T G.8271.1 Network Limit clause 7.3	ITU-T G.8262.1 clause 9 (see note)
Class D	For Further Study	For Further Study

Note:

ITU-T G.8262.1 clause 9 specifies two levels of wander tolerance:

1. **Clause 9.1 (Level 1)** specifies tolerance requirements for enhanced equipment clocks that are used in reference chains containing enhanced synchronous equipment clocks (eEECs) only; this level is lower (tolerates less noise) than Level 2.

2. **Clause 9.2 (Level 2)** specifies tolerance requirements for enhanced equipment clocks that are used in reference chains containing a mix of G.8262 synchronous equipment clocks (EEC) and enhanced synchronous equipment clocks (eEECs). This tolerance level is higher (tolerates more noise) than Level 1 and is identical to the noise tolerance specified in ITU-T G.8262 clause 9.1.1.

Measurement Process

1. Confirm that the DUT is correctly connected to Paragon-neo and the settings within the **PTP emulation** app are appropriate for the current test scenario as described in Sections 3 and 4.

2. To test to the measurement methodology specified in ITU-T G.8273, ensure the **Background Traffic** app is configured as described in Section 4.5.

3. The test type is dependent on the device class and, for Class C clocks, the SyncE reference chain type. From the **Test:** drop-down menu:

   - For **Class A/B** conformance select **Noise Tolerance (Clause 7.2.1).**

   - For **Class C** select **Noise Tolerance Class C eEEC Only Chain (Clause 7.2.2)** or **Noise Tolerance Class C Mixed eEEC & EEC Chain (Clause 7.2.2)** depending on the tolerance level to be tested.

   For the greatest utility within a network, a Class C clock should be able to tolerate mixed chain (G.8262 / G.8262.1 Level 2) noise.
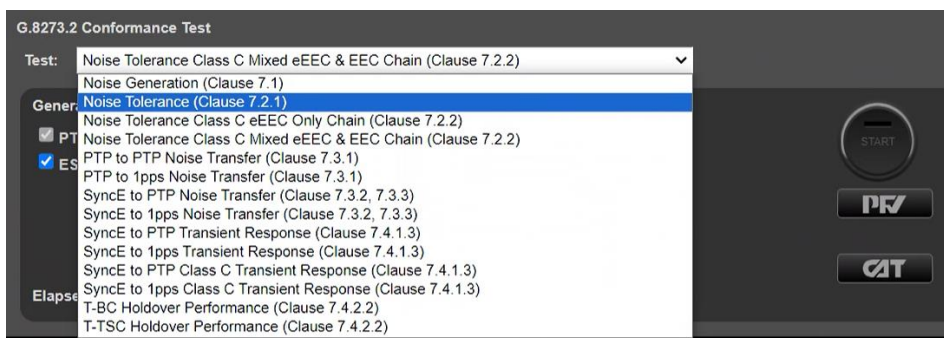
4. From the **Generation** section of the **Conformance Test** app, press **Generate**.

    This starts PTP and ESMC message generation allowing the DUT to stabilize. Pressing **Check** will open the CAT in a new tab allowing you to check current timing performance. In this case, you should wait for the **1PPS TE Absolute measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.

5. Once the DUT is stable, in the **Stimulus/Measurement** section, press **Start** to run the Noise Tolerance test. PTP and SyncE Stimulus as per the relevant clause of G.8273.2 will be applied and the capture will start.
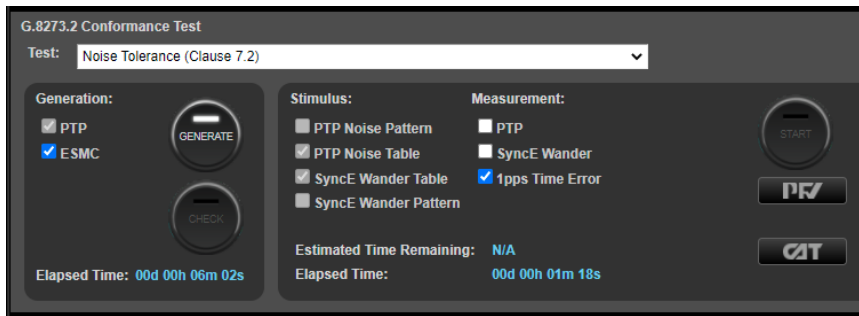
6. Once the test stimuli have finished, select **Stop Capture** to end the measurement.

Results Analysis

The expected outcome is that the DUT should remain locked to the reference and not switch reference or enter holdover state. This must be determined from the device itself (e.g. via the management interface).

Further Analysis (optional)

As a 1PPS measurement is performed by Paragon-neo during this test, an indication of DUT lock may also be determined by viewing the Time Error performance in CAT. The timing behavior of the DUT under the tolerance conditions may be further analyzed.

7 Noise Transfer – G.8273.2 Clause 7.3

Test Description

This test measures how Time Error on the input is transferred to the output.

Measurement Process

1. Confirm that the DUT is correctly connected to Paragon-neo and the settings within the **PTP emulation** app are appropriate for the current test scenario as described in Sections 3 and 4.

2. To test to the measurement methodology specified in ITU-T G.8273, ensure the **Background Traffic** app is configured as described in Section 4.5.

3. Follow the steps in the sections below that apply to the DUT.

7.1 PTP to 1PPS Transfer (Clause 7.3.1)

1. From the **Test:** drop-down menu, select **PTP to 1PPS Noise Transfer (Clause 7.3.1).**
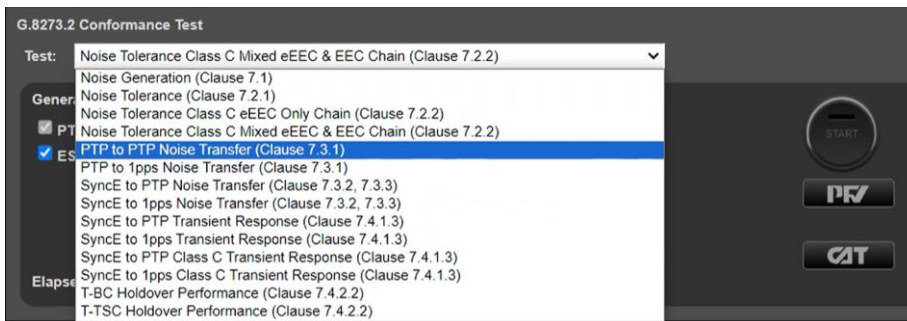
2. From the **Generation** section of the **Conformance Test** app, press **Generate.** This starts PTP and ESMC message generation allowing the DUT to stabilize. Pressing **Check** will open the CAT in a new tab allowing you to check current timing performance. In this case, you should wait for a **1PPS TE Absolute measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.

3. Once the DUT is stable, in the **Stimulus/Measurement** section, press **Start** to run the prescribed PTP Noise Stimulus and simultaneous 1PPS measurement.
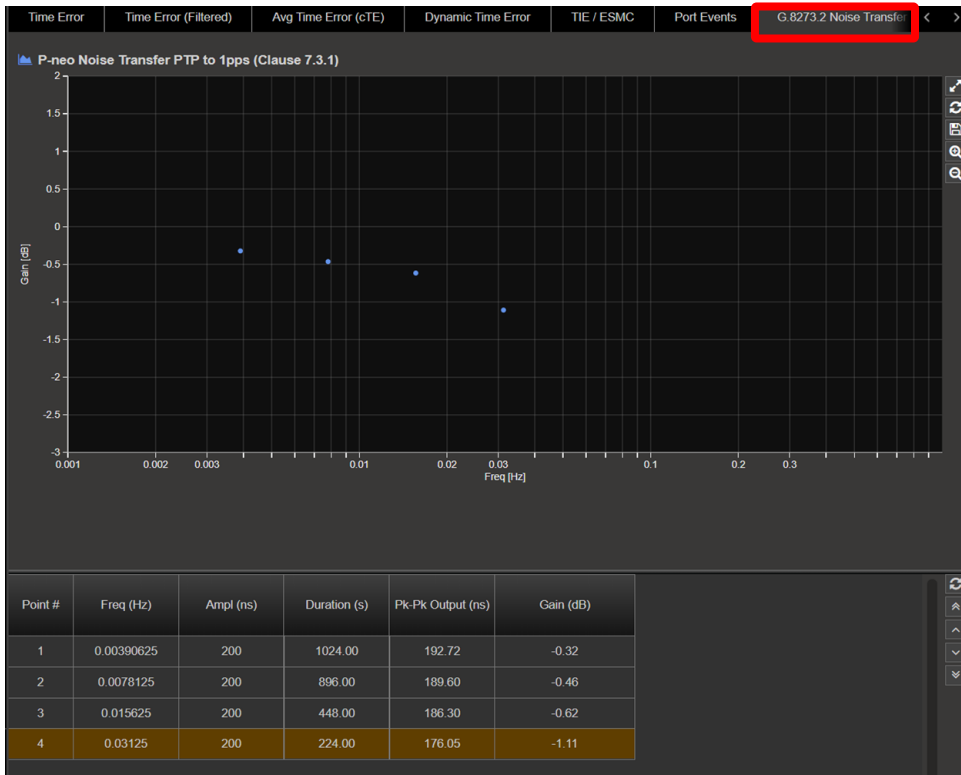
   PTP Noise (Time Error) is applied as per G.8273.2 Amendment 1 (Appendix VI).

   For more information on the test considerations and the approach to test in the ITU-T recommendation, please see the Calnex application note **Time Error Transfer for BCs**.

Results Analysis

5. During or after the test, CAT can be launched to view the results – complete PTP-1PPS transfer results are available in the **G.8273.2 Noise Transfer (Clause 7.3)** tab.

A Bode plot is displayed along with a table of applied stimulus vs. gain. If a test step is still underway, this will be highlighted in orange on the table.


Point #	Freq (Hz)	Ampl (ns)	Duration (s)	Pk-Pk Output (ns)	Gain (dB)
1	0.00390625	200	1024.00	192.72	-0.32
2	0.0078125	200	896.00	189.60	-0.46
3	0.015625	200	448.00	186.30	-0.62
4	0.03125	200	224.00	176.05	-1.11

6. By selecting the mask applicable to the DUT class in **Masks (**from the right-hand side of the CAT), max/min pk-pk values as per the standard will be displayed in the table, along with limit lines on the graph.

Note that the pk-pk limits as defined in G.8273.2 are defined as a value *+N* to account for added noise generation of the DUT. The value of *N* = **10ns** has been selected for the pass/fail limits as this provides the balance between the ability to measure accurately and give confidence that the DUT is meeting its requirements. More information can be found on the Calnex online FAQ:
https://calnexsolutions.atlassian.net/wiki/spaces/KB/pages/2031620/G.8273.2+7.3.1+7.3.2+Noise+Transfer

7. The T-TSC performance meets requirements when the output is within the applied mask. The Pass/Fail status is indicated in the **Mask Status** block in the top-right area of the CAT display.
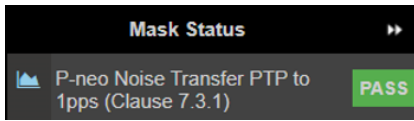
7.2 SyncE to 1PPS Transfer (Clause 7.3.2, 7.3.3)

1. From the **Test:** drop-down menu, select **SyncE to 1PPS Noise Transfer (Clause 7.3.2, 7.2.3).**
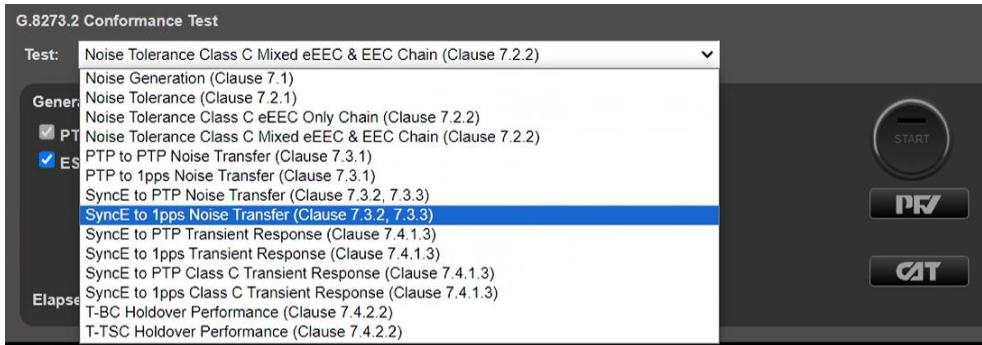
2. From the **Generation** section of the **Conformance Test** app, press **Generate.** This starts PTP and ESMC message generation allowing the DUT to stabilize. Pressing **Check** will open the CAT in a new tab allowing you to check current timing performance. In this case, you should wait for a **1PPS TE Absolute measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.

3. Once the DUT is stable, in the **Stimulus/Measurement** section, press **Start** to run the prescribed SyncE Noise Stimulus and simultaneous 1PPS measurement.

Results Analysis

1. During or after the test, CAT can be launched to view the results – complete SyncE-1PPS transfer results are available in the **G.8273.2 Noise Transfer (Clause 7.3)** tab.

   A Bode plot is displayed along with a table of applied stimulus vs. gain. If a test step is still underway, this will be highlighted in orange on the table.

| Point #	Freq (Hz)	Ampl (ns)	Duration (s)	Pk-Pk Output (ns)	Gain (dB)
1	0.00391	2000	1023.02	0.01	-100.00
2	0.00781	2000	896.29	0.01	-100.00
3	0.01563	2000	447.86	0.01	-100.00
4	0.03125	1000	224.00	0.02	-92.61
5	0.06156	500	243.66	0.03	-83.51
6	0.12313	250	251.77	0.04	-75.24

2. By selecting the mask applicable to the DUT class in Masks (from the right-hand side of the CAT), max/min pk-pk values as per the standard will be displayed in the table, along with limit lines on the graph.

Note that the pk-pk limits as defined in G.8273.2 are defined as a value +N to account for added noise generation of the DUT. The value of **N = 25ns** has been selected for the pass/fail limits as this provides the balance between the ability to measure accurately and give confidence that the DUT is meeting its requirements. More information can be found on the Calnex online FAQ:
https://calnexsolutions.atlassian.net/wiki/spaces/KB/pages/2031620/G.8273.2+7.3.1+7.3.2+Noise+Transfer

3. The T-TSC performance meets requirements when the output is within the applied mask. The Pass/Fail status is indicated in the **Mask Status** block in the top-right area of the CAT display.
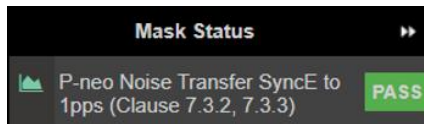
8 Transient Response – G.8273.2 Clause 7.4.1

Test Description

Short-term transient response refers to the time error generated when a clock switches over from one input reference to another e.g. in the event of a reference failure.

A reference switch in the physical layer frequency reference at the previous node to the T-TSC can generate a large transient in the T-TSC input, therefore a T-TSC must reject this transient. It can achieve this by monitoring the ESMC messages on the SyncE interface.

On receipt of a degraded QL, the T-TSC must either stop using the SyncE signal, or turn off the low-pass filter, allowing the PTP to correct the time error more quickly. When traceability of the SyncE signal is restored, the T-TSC can go back to using the SyncE signal.

Annex B of G.8273.2 (06/23) defines the following mask for the output of **T-TSC Classes A and B** in the event of a transient on the SyncE input:
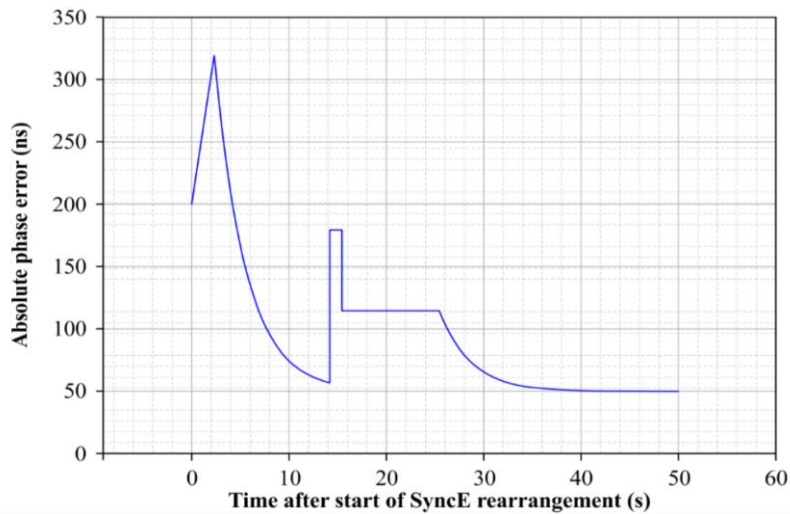

Figure B.1 from G.8273.2 Annex B – Phase error mask during a physical layer transient

The method to verify compliance with the mask shown above is described in **G.8273 Appendix III**. The phase transient to be applied to the input SyncE signal is shown below. During the transient, the input QL-value in the ESMC messages is changed from QL-PRC to QL-EEC in the first shaded area (from 1.8s to 2.0s), and back to QL-PRC in the second shaded area (from 15.18s to 15.5s).
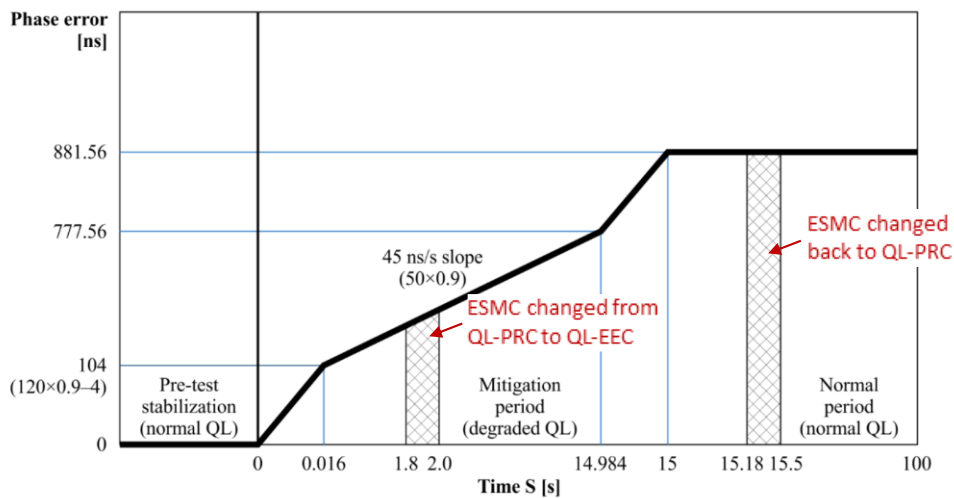

Fig. III.2 from G.8273 Appendix III – SyncE Transient Input Pattern

Annex C of G.8273.2 (06/23) defines the following mask for the output of **T-TSC Classes C and D** in the event of a transient on the SyncE input:
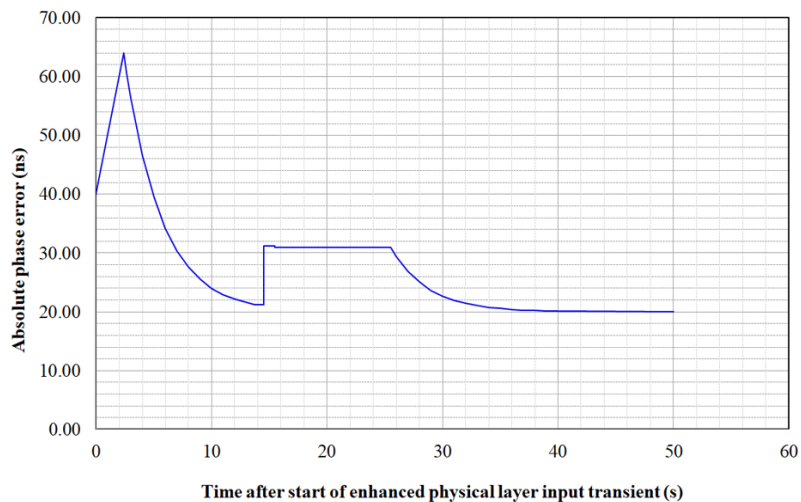

Figure C.1 from G.8273.2 Annex C – Phase error mask during an enhanced physical layer transient

The method to verify compliance with the mask shown above is described in **G.8273 Appendix III**. The phase transient to be applied to the input SyncE signal is shown below. During the transient, the input QL-value in the ESMC messages is changed from QL-PRC to QL-EEC in the first shaded area (from 1.8s to 2.0s), and back to QL-PRC in the second shaded area (from 15.18s to 15.5s).
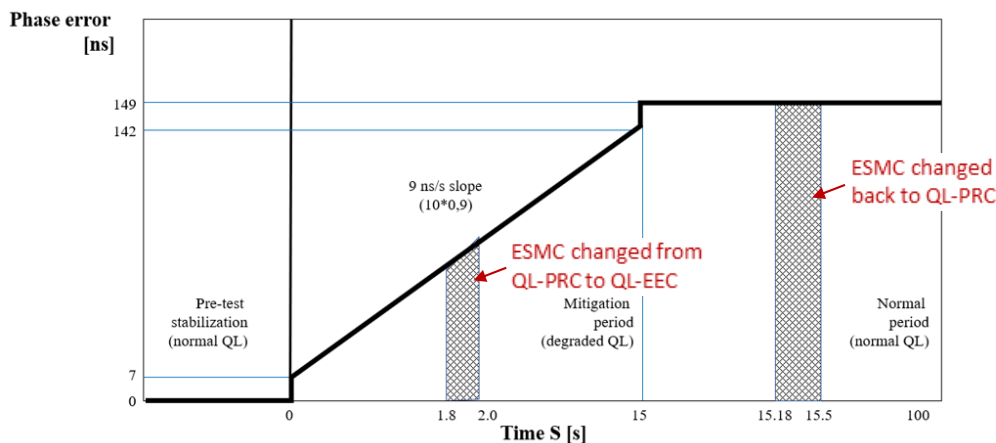

**Figure III.3 –Test Case 1 enhanced synchronous equipment clock (e.g., eSyncE) transient input pattern**

Fig. III.3 from G.8273 Appendix III – SyncE Transient Input Pattern

Measurement Process

1. Confirm that the DUT is correctly connected to Paragon-neo and the settings within the **PTP Emulation** app are appropriate for the current test scenario as described in Sections 3 and 4.

2. To test to the measurement methodology specified in ITU-T G.8273, ensure the **Background Traffic** app is configured as described in Section 4.5.

3. Follow the steps in the sections below that apply to the DUT.

8.1   SyncE to 1PPS Transient Response (Clause 7.4.1.3)

1. The test type is dependent on the device class. From the **Test:** drop-down menu:

   - For **Class A/B** conformance select **SyncE to 1PPS Transient Response (Clause 7.4.1.3)**

   - For **Class C** conformance select: **SyncE to 1PPS Class C Transient Response (Clause 7.4.1.3)**
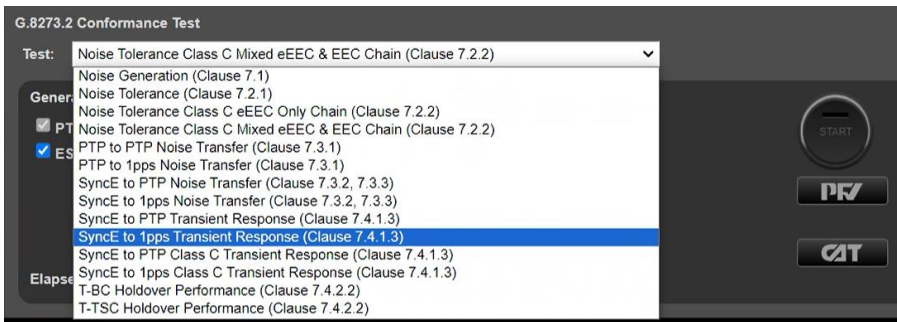
2. From the **Generation** section of the **Conformance Test** app, press **Generate.** This starts PTP and ESMC message generation allowing the DUT to stabilize.

   Pressing **Check** will open the CAT in a new tab allowing you to check current timing performance. In this case, you should wait for a **1PPS TE Absolute measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.

3. Once the DUT is stable, in the **Stimulus/Measurement** section, press **Start** to run the prescribed SyncE wander and ESMC state change stimulus and simultaneous 1PPS measurement.

   The test process measures for a period of time before the application of the transient. This allows the CAT to calculate and adjust for the Constant Time Error (cTE) as specified in ITU-T G.8273 Annex B for correct analysis of the DUT transient response – **For the Class A/B test the cTE analysis time is 100s** with a total test time of approximately 200s; **for the Class C test the cTE analysis time is 1000s** with a total test time of approximately 1100s.

Results Analysis

1. In the CAT, click on **Select Metrics** and enable the **G.8273.2 Transient Response** metric followed by the **Calculate** button.

   All other metrics can be unchecked if required to limit conformance checking to the relevant metric only.
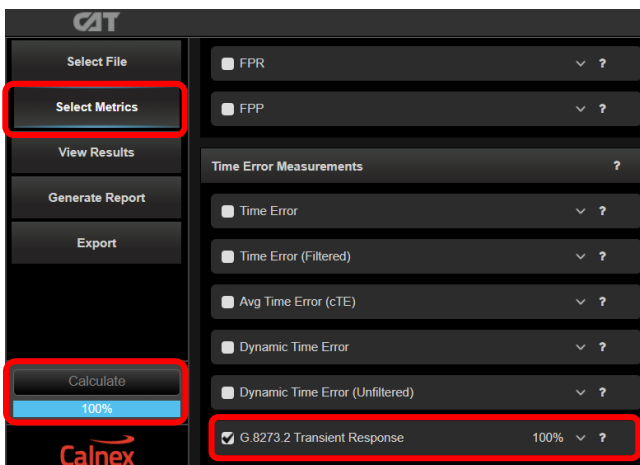
NOTE: Due to the application of the transient event, the other Time Error results will be impacted and thus cannot be relied upon to provide representative results – other aspects of Time Error performance should be analyzed in separate test runs.

2. Select **View Results** and navigate to the **G.8273.2 Transient Response** tab. The device Class A & B mask is automatically applied; this can be changed if required.

3. Select the mask that is applicable to the class of conformance test run:

DUT Class	Dynamic MTIE LF Mask
Class A & B	G.8273.2 Class A & B Phase Error
Class C	G.8273.2 Class C Phase Error
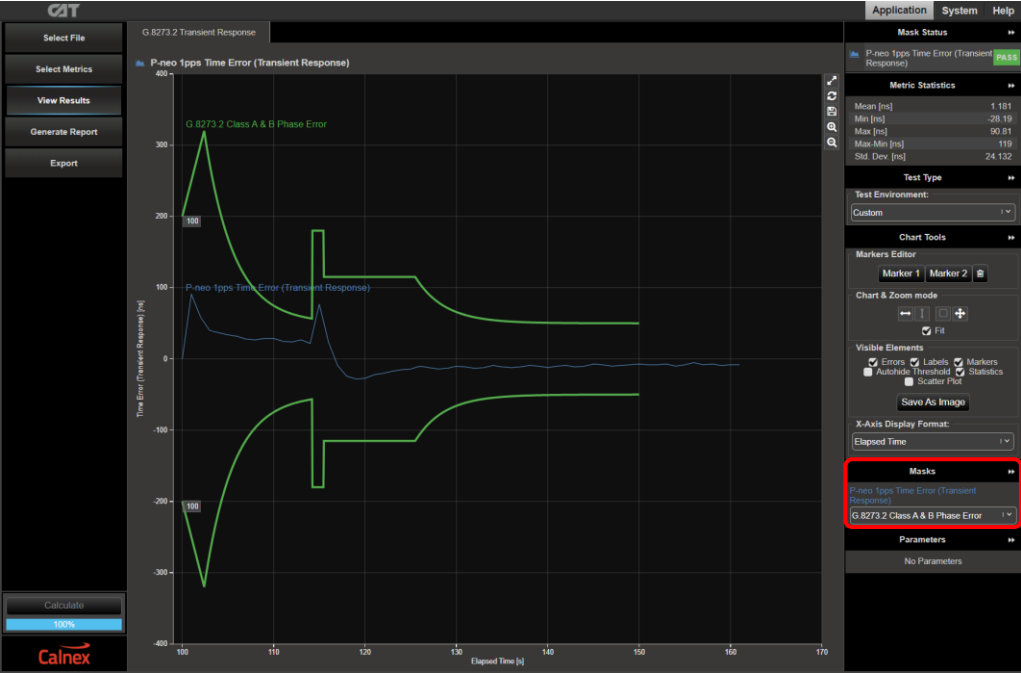
4. T-TSC performance meets requirements when the output is within the applied mask. The Pass/Fail status is indicated in the top-right area of the CAT display.
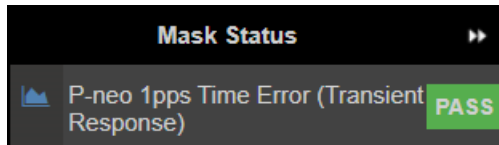
9 Holdover Performance (Clause 7.4.2)

Test Description

Holdover performance is checked by measuring the phase/time output in the event of the loss of the PTP input to the T-TSC.

Currently, only Classes A and B have defined limits for holdover performance, however, there are different limits for constant and variable temperature conditions; the table below shows the limits that apply.
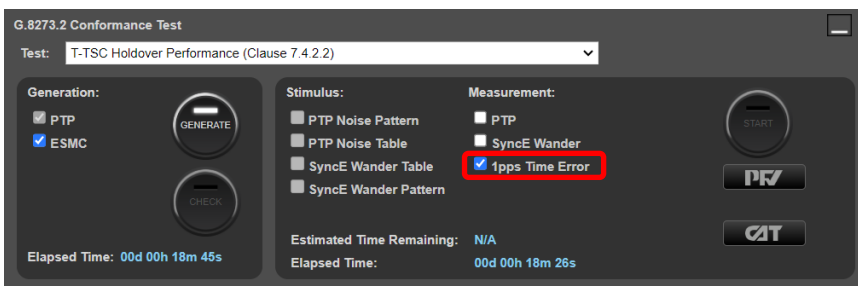
DUT Class	Constant Temperature Limit	Variable Temperature Limit
Class A & B	G.8273.2 Table 7-10, Fig 7-1	G.8273.2 Table 7-11, Fig 7-2

Measurement Process

1. Confirm that the DUT is correctly connected to Paragon-neo and the settings within the **PTP emulation** app are appropriate for the current test scenario as described in Sections 3 and 4.

2. Configure the device test environment for either a constant or variable temperature test; guidelines for variable temperature testing are described in Appendix I of ITU-T G.8273.

3. To test to the measurement methodology specified in ITU-T G.8273, ensure the **Background Traffic** app is configured as described in Section 4.5.

4. From the **Test:** drop-down menu, select **T-TSC Holdover performance (Clause 7.4.2.2).**
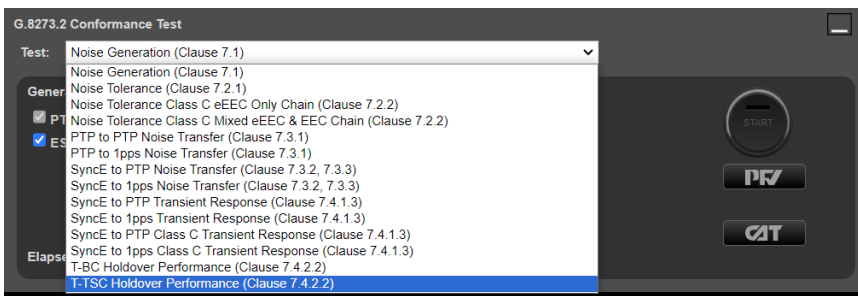
5. From the **Measurement** section of the **Conformance Test** app, check the **1pps Time Error** checkbox.

6. From the **Generation** section of the **Conformance Test** app, press **Generate.** This starts PTP and ESMC message generation allowing the DUT to stabilize.

   Pressing **Check** will open the CAT in a new tab allowing you to check current timing performance. In this case, you should wait for the **1pps TE Absolute measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.

7. Once the DUT is stable, in the **Stimulus/Measurement** section, press **Start** to simulate loss of PTP input signal to the DUT and make simultaneous PTP performance measurements.

   The minimum duration for a constant temperature test is 1000 seconds, for a variable temperature test it is 10,000 seconds.
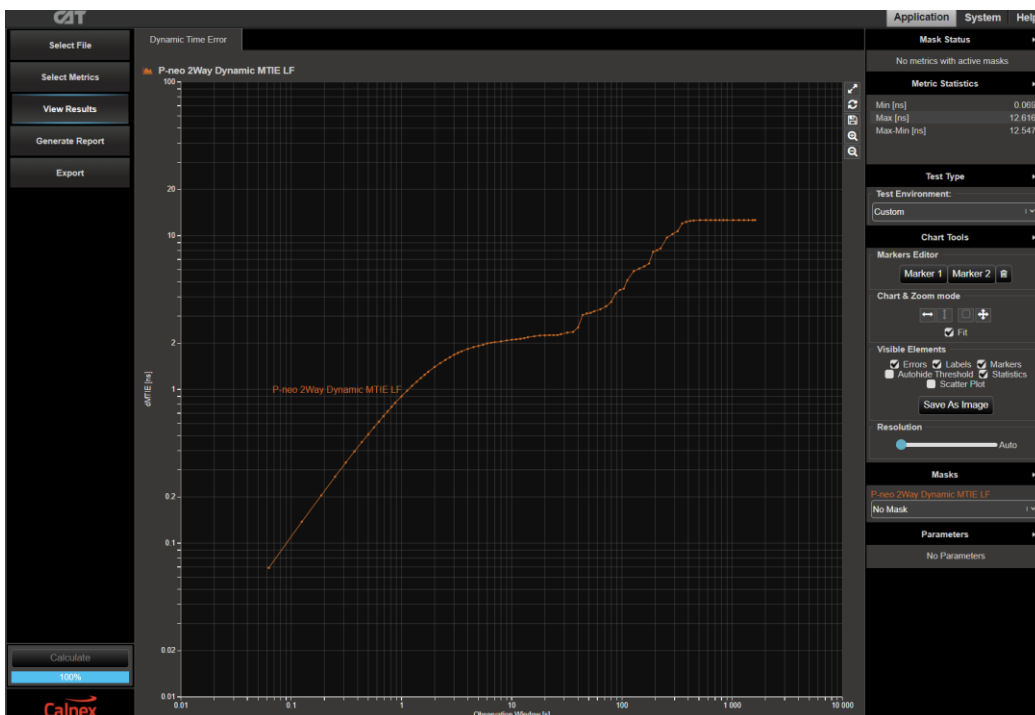
8. In the **Stimulus/Measurement** section, press **Stop** to stop the test.

Results Analysis

1. In the CAT, click on **Select Metrics** and ensure the **P-neo 1pps TE Absolute Dynamic MTIE LF** is enabled. Disable all other metrics, then press the **Calculate** button.
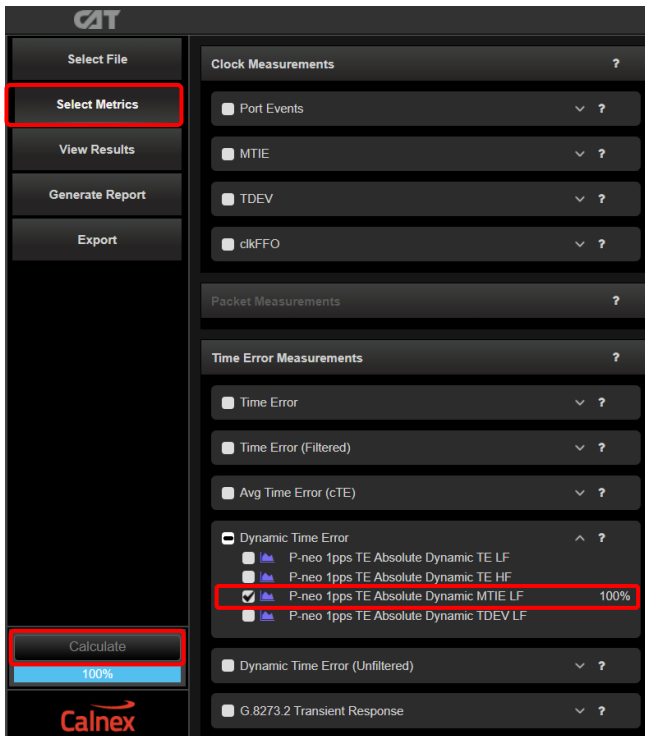

2. Select **View Results** and the **Dynamic Time Error** tab will be displayed.

3. Select the appropriate mask for the device class and the temperature conditions of the test, the "…T-BC…" masks also apply to T-TSC devices:

Device Class	Dynamic MTIE LF Mask	
	Constant Temperature	Variable Temperature
Class A	G.8273.2 T-BC Class A Time Holdover Const. Temp.	G.8273.2 T-BC Class A Time Holdover Var. Temp.
Class B	G.8273.2 T-BC Class B Time Holdover Const. Temp.	G.8273.2 T-BC Class B Time Holdover Var. Temp.
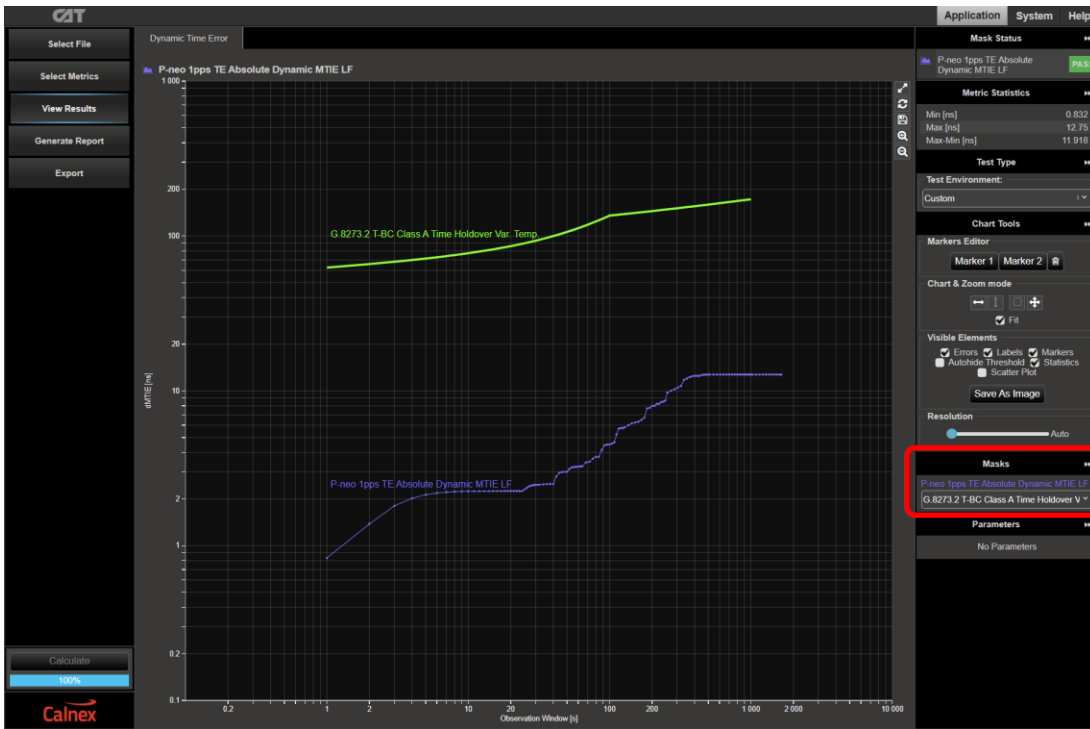
4. The T-TSC performance meets requirements when the output is within the applied mask. The Pass/Fail status is indicated in the **Mask Status** block in the top-right area of the CAT display.
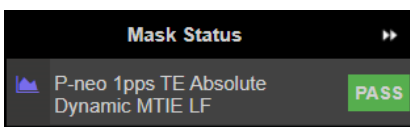
Appendix 1 – Tests for a G.8273.2 T-TSC

Note that where a metric has different values for both constant and variable temperature conditions, it is the values for constant temperature that have been used in the table below. The individual test sections in this document have information regarding differences between requirements depending on the temperature conditions.

Test	Objective	Test Method	Output Limit (PTP and 1PPS) [1]				
Time Error Generation (G.8273.2, Section 7.1)	With stable input references, measure the inherent time error (Max$|TE_L|$, Max$|TE|$, cTE and dTE) produced by the internal clock.	Apply a stable time reference to the PTP input. Apply a stable frequency reference to the SyncE input. Repeat without a SyncE reference[2].		**Class A**	**Class B**	**Class C**	**Class D**
			Max$|TE_L|$:[3]	-	-	-	≤ 5ns
			Max$|TE|$:[4]	≤ 100ns	≤ 70ns	≤ 30ns	FFS
			cTE:	≤ 50ns	≤ 20ns	≤ 10ns	FFS
			dTE_{LF}:[5]	40ns MTIE, 4ns TDEV		10ns MTIE 2ns TDEV	FFS
			dTE_{HF}:[6]	70ns p-p		30ns p-p	FFS
Time Error Tolerance (G.8273.2, Section 7.2)	Measures whether the clock can operate correctly with maximum noise input at the input. The test must be carried out with noise on both the PTP and SyncE inputs. Clock under test should not: • generate alarms • switch reference • go into holdover	**Combined PTP and SyncE tolerance:** Apply Calnex noise tolerance profile to the PTP input[7] [8] Simultaneously apply sine wave phase wander to the SyncE input according to G.8262, Table 9. Repeat without a SyncE reference[7].	No output performance limit. Clock under test should not: • generate alarms • switch reference • go into holdover				

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[1] Same limits apply to 1PPS and PTP outputs. It is assumed that the 1PPS should track the PTP output closely, although there is no specification for how closely they should track.

[2] G.8273.2 doesn't currently specify the performance in the absence of SyncE, therefore repeating the test without the use of SyncE input reference is optional.

[3] Max$|TE_L|$ is calculated on time error data after low-pass filtering by 0.1Hz.

[4] Max$|TE|$ is calculated on the raw, unfiltered time error data.

[5] MTIE and TDEV are calculated after low-pass filtering by 0.1Hz. Same values apply to both Class A and Class B devices.

[6] TIE is measured after high-pass filtering by 0.1Hz. Same values apply to both Class A and Class B devices.

[7] This profile is derived from the dTE network limit MTIE mask, defined in G.8271.1 Figure 7-2.

[8] Values assume a first order, 20dB/decade filter, with ±35ns (70ns p-p) noise from the output packet interface. For higher-order or digital filters, or for lower noise different values will apply.

Test	Objective	Test method	Output Limit (PTP and 1PPS)[1]
Time Error Transfer (G.8273.2, Section 7.3)	Measures how time error on the input is transferred to the output. **PTP-to-1PPS transfer function**: • Low-pass filter (undefined order or shape) • Bandwidth from 0.05 to 0.1Hz **SyncE-to-1PPS transfer function**: • Band-pass filter (undefined order or shape) • Lower cut-off from 0.05 to 0.1Hz • **Class A/B** Upper cut-off from 1 to 10Hz • **Class C/D** Upper cut-off from 1 to 3Hz	**PTP to 1PPS:** Apply a set of sine wave PDV modulations of 400ns p-p amplitude (i.e. 200ns time error when applied in one direction) at several different frequencies. Apply a stable frequency reference to the SyncE input. Repeat without a SyncE reference.[2]	Maximum and minimum gain and amplitude values described in G.8273.2 Table VI.4. Values in the table assume a first order, 20dB/decade filter. Class D is not referenced in the above table so it is assumed that the same values currently apply, as clause 7.3.1 does not differentiate between classes.
		SyncE to 1PPS: Apply a stable time reference to the PTP input. Apply a set of sine wave phase modulations several different frequencies and amplitudes.	Maximum and minimum gain and amplitude values described in G.8273.2 Table VI.8 (Class A & B) and VI.9 (Class C). Values in the table assume a first order, 20dB/decade filter. Class D is not referenced in the tables above, so it is assumed that the Class C values currently apply as clause 7.3.3 references both Class C and D.
Transient Response (G.8273.2, Section 7.4.1, plus Annexes B & C, Appendix III)	Measure the transient caused by a switch between PTP timeTransmitters.	No test method defined.	No performance limit defined
	Measure the response to a SyncE rearrangement transient.	Apply a stable time reference to the PTP input. Apply a stable frequency reference to the SyncE input. After the T-TSC has locked onto the inputs and stabilised, apply the transient defined in G.8273 Figure III.2 (Class A/B) or Figure III.3 (Class C) to the SyncE input, coupled with changing the ESMC QL values at the times defined in G.8273 Appendix III.	Phase mask defined in G.8273.2 Annexes B and C.
Holdover Performance (G.8273.2, Section 7.4.2 7.4, plus Annexes B & C, Appendix III)	Measures the response to entry into holdover caused by loss of packets at PTP input.	Apply a stable time reference to the PTP input. Apply a stable frequency reference to the SyncE input. After the T-TSC has locked onto the inputs and stabilised, stop the flow of PTP packets, and monitor the output for up to 1000s.	MTIE mask defined in G.8273.2, Table 7-6

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[1] Same limits apply to 1PPS and PTP outputs. It is assumed that the 1PPS should track the PTP output closely, although there is no specification for how closely they should track.

[2] G.8273.2 doesn't currently specify the performance in the absence of SyncE, therefore repeating the test without the use of SyncE input reference is optional.

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