TEST GUIDE

CX3009 v5.0

G.8273.2 BC Conformance Test

Testing Boundary Clocks 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 Telecom Boundary Clocks (T-BCs) 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-BCs 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-BC 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.

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-RTE*	PTP Testing – Relative Time Error
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)
- Calnex PFV Getting Started Guide
- Calnex Paragon-neo Getting Started Guide. The guide is provided with Paragon-neo document set or download here: https://calnexsolutions.atlassian.net/wiki/spaces/KB/pages/28508216/User+Guides

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.

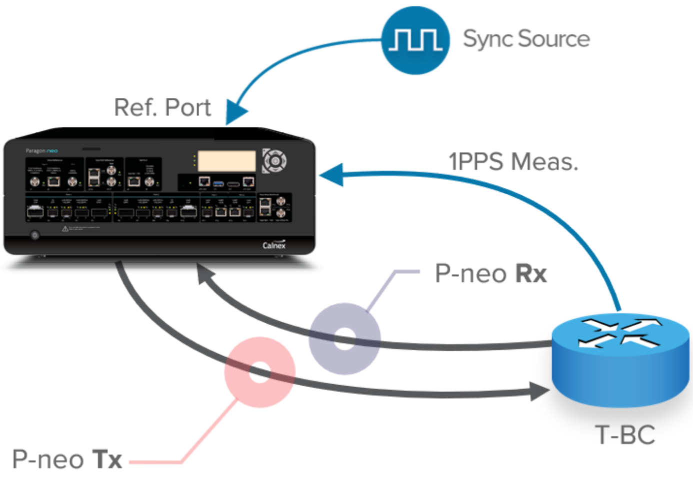
The Calnex Sentinel and Paragon-x products can be used to capture real-life network performance and can be imported into Paragon-neo as impairment profiles.

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

The physical connections between Paragon-neo and the DUT depend on the type of test to be run and the output signals to be measured from the DUT. The various scenarios are detailed below.

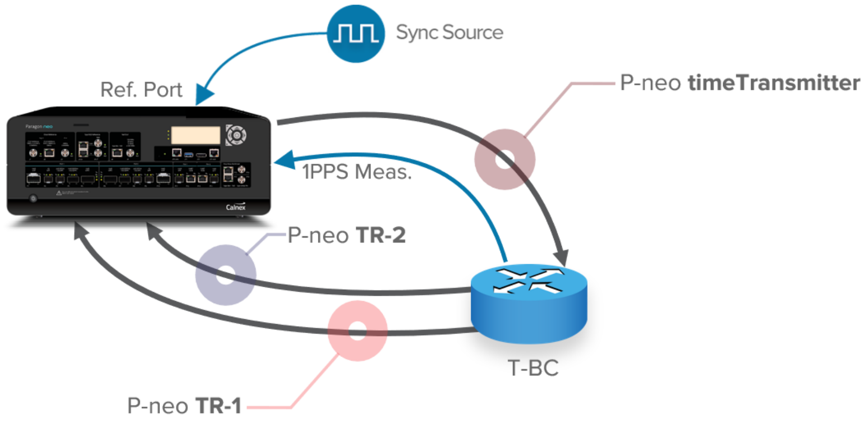
Information regarding the Paragon-neo front panel connections and interface are detailed in the **Calnex Paragon-neo Getting Started Guide**. This document is provided as part of the Paragon-neo on-instrument document set, accessible from the **Help** menu in the top right of the Paragon-neo Graphical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

3.1 Connections for Tests (excluding Relative Time Error Tests)



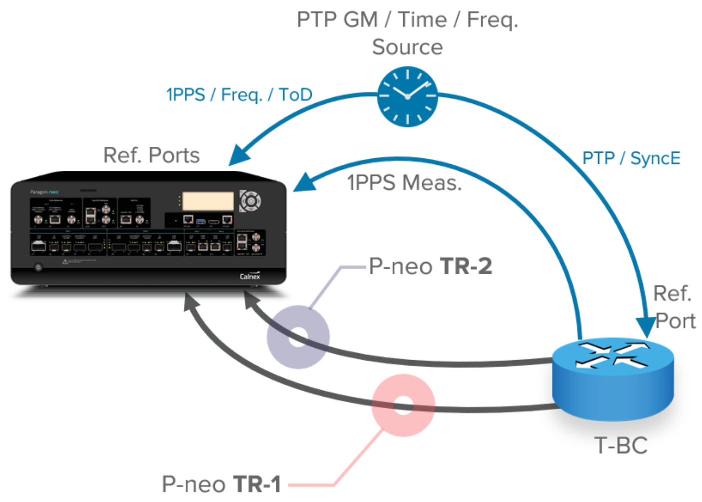
1. Connect Port 1 (timeTransmitter side of Paragon-neo) to the T-BC timeReceiver side.
2. Connect Port 2 (timeReceiver side of Paragon-neo) to the T-BC timeTransmitter side.
3. If desired, connect an external reference, e.g. 10MHz, to the Paragon-neo Reference input.
4. If provisioned on the DUT, connect the 1PPS output from the T-BC to the Paragon-neo 1PPS Measurement port.

3.2 Connections for PTP vs. PTP/1PPS Relative Time Error Tests, or for Two Simultaneous PTP Measurements – using the Paragon-neo RTE timeTransmitter Port



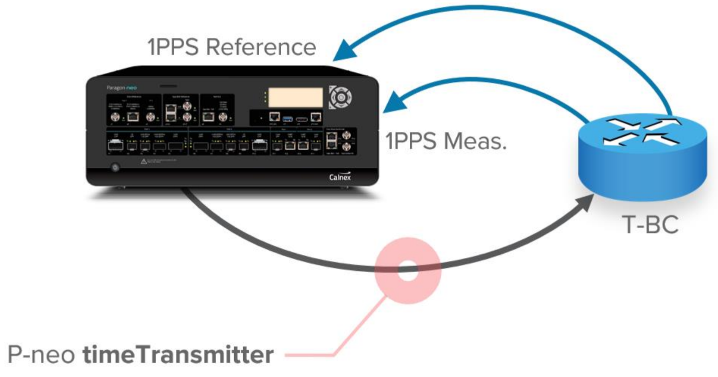
1. Connect Paragon-neo Port 1 (which will be labelled as timeReceiver 2 and TR 2 in the GUI and CAT) to a T-BC timeTransmitter port.
2. Connect Paragon-neo Port 2 (which will labelled as timeReceiver 1 and TR 1 in the GUI and CAT) to a T-BC timeTransmitter port.
3. Connect the Paragon-neo RTE timeTransmitter port (labelled Port 2 100M SFP on the instrument front panel, and TT-RTE in the Setup Ports screen in the GUI) to a T-BC timeReceiver port. Note that in Relative Time Error test mode, this port runs at 1G and not 100M.
4. If provisioned on the DUT, connect the 1PPS output from the T-BC to the Paragon-neo 1PPS Measurement port.
5. Essential for two simultaneous PTP measurements, and optional for Relative Time Error: connect phase (1PPS), frequency (e.g. 10MHz) and, optionally, ToD references to the Paragon-neo Reference inputs.

3.3 Connections for PTP vs. PTP/1PPS Relative Time Error Tests, or for Two Simultaneous PTP Measurements – using an External PTP Grandmaster



1. Connect Paragon-neo Port 1 (which will be labelled as timeReceiver 2 and TR-2 in the GUI and CAT) to a T-BC timeTransmitter port.
2. Connect Paragon-neo Port 2 (which will labelled as timeReceiver 1 and TR 1 in the GUI and CAT) to a T-BC timeTransmitter port.
3. Connect the external PTP GM PTP timeTransmitter port to a T-BC timeReceiver port.
4. If not provided on the same port as the PTP, connect the PTP GM physical layer frequency source (typically SyncE) to a T-BC Frequency Reference port.
5. If provisioned on the DUT, connect the 1PPS output from the T-BC to the Paragon-neo 1PPS Measurement port.
6. Essential for two simultaneous measurements and optional for Relative Time Error: connect phase (1PPS), frequency (e.g. 10MHz) and, optionally, ToD references to the Paragon-neo Reference inputs.

3.4 Connections for 1PPS vs 1PPS Relative Time Error Test



1. Connect the Paragon-neo 1PPS Reference port to a T-BC 1PPS output port.
2. Connect the Paragon-neo 1PPS Measurement port to a second T-BC 1PPS output port.
3. Connect Paragon-neo Port 1 (which will be labelled as timeTransmitter in the GUI and Calnex Analysis Tool (CAT)) to the T-BC timeReceiver port. This port will also provide SyncE to the T-BC.
4. If desired, connect an external frequency reference (e.g. 10MHz) to the Paragon-neo Frequency 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

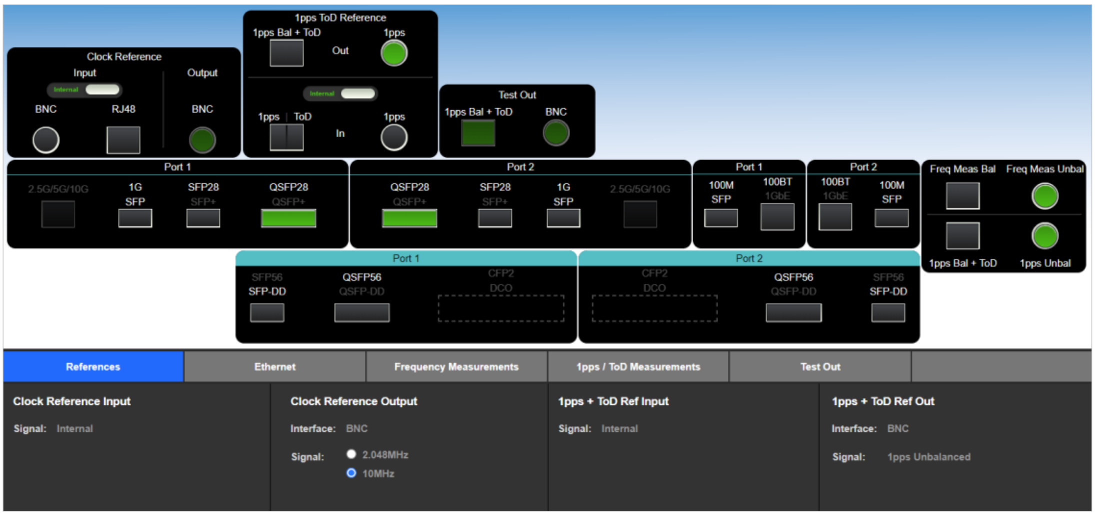
4.5 Background Traffic

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

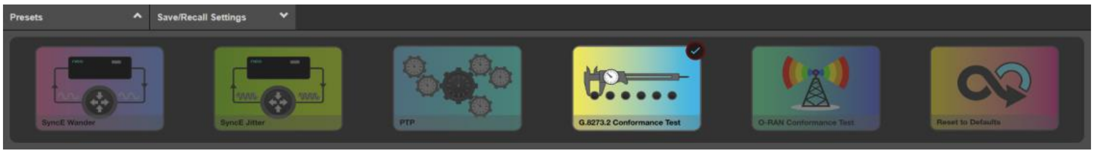
1. Select **Setup Ports** from the onscreen display and select those reference and test ports to be used.
2. If required, enter **Threshold** and **Termination** information for 1PPS signals. Voltage thresholds should be set to one decimal place to ensure best accuracy of test and measurement.



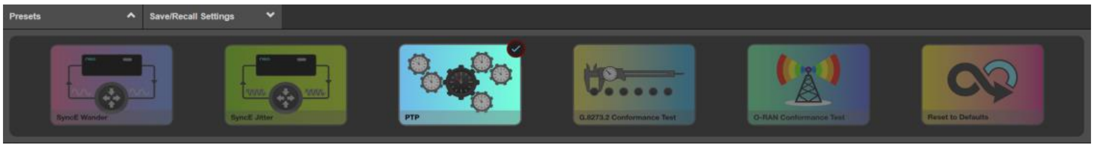
4.3 Test Configuration

1. Select **Run Apps,** then the required preset.

For all T-BC tests <u>except</u> Relative Time Error, select the **Conformance Test** preset**:**



For Relative Time Error tests, select the **PTP** preset:



4.4 Device Connection Settings

It is assumed that a G.8275.1 profile will be used in testing as per the G.8273.2 standard and 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. For all conformance tests apart from Relative Time Error Noise Generation, in the **PTP Emulation** app, select **Boundary Clock** as the **Test Mode.**

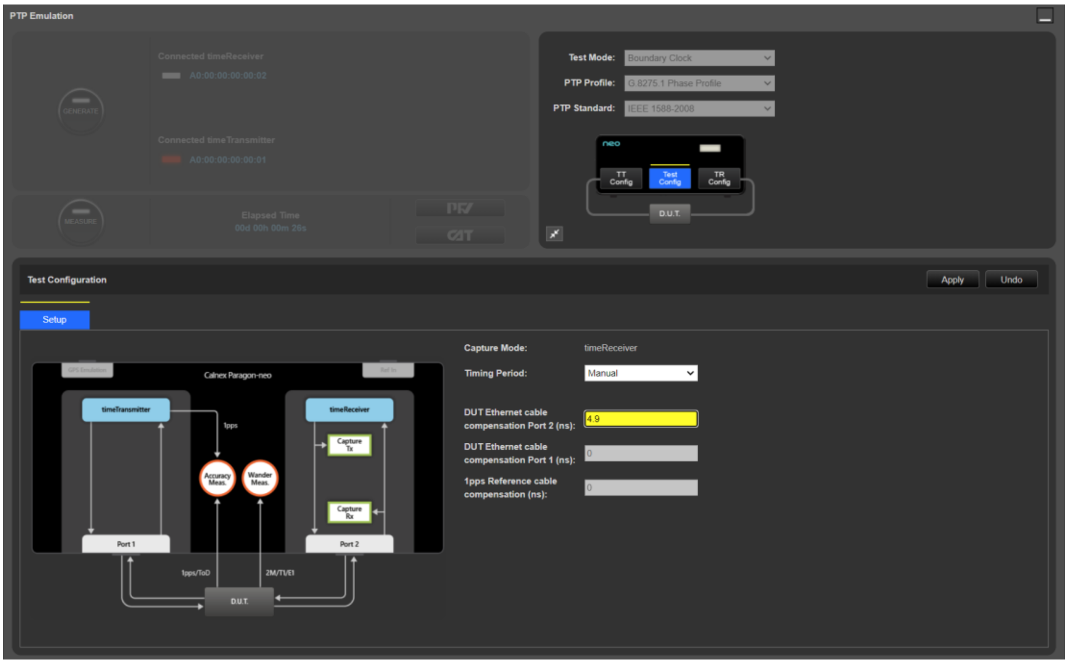
   For PTP vs. PTP/1PPS Relative Time Error testing or to make two simultaneous PTP measurements, in the **PTP Emulation** app, select **Relative Time Error / 2 x TE** as the **Test Mode.** Note that in this mode separate cable compensation values must be entered for Port 1 and Port 2.

   For 1PPS vs. 1PPS Relative Time Error testing, in the **PTP Emulation** app, select **timeReceiver**. This will cause Paragon-neo to emulate a timeTransmitter instance which will be used as the DUT PTP reference.

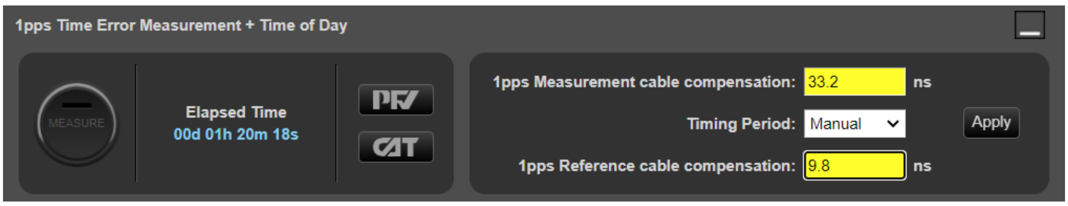
2. In the **PTP Emulation** app, select **G8275.1 Phase Profile** as the **PTP Profile** then select the required PTP Standard (IEEE-1588 2008 or IEEE-1588 2019).

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. A value of 4.9ns per meter of single-mode optical fiber and 4.94ns/m of multi-mode fiber is typical, but for the best accuracy of device measurement, the specific value for the fiber used should be confirmed as per its datasheet. For the coaxial cable used for 1PPS (unbalanced) signals, 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, make any necessary cable delay compensation settings.



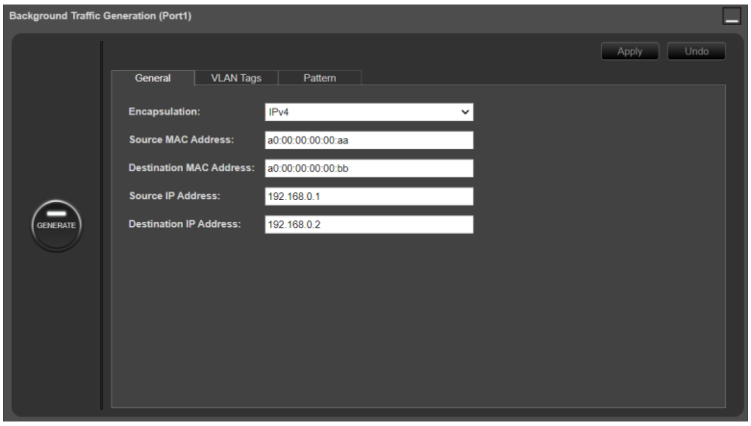
   Further information to assist with entering cable delay values is provided in the **Quick Help** in the left-hand pane within the Paragon-neo GUI.

4.5 Background Traffic

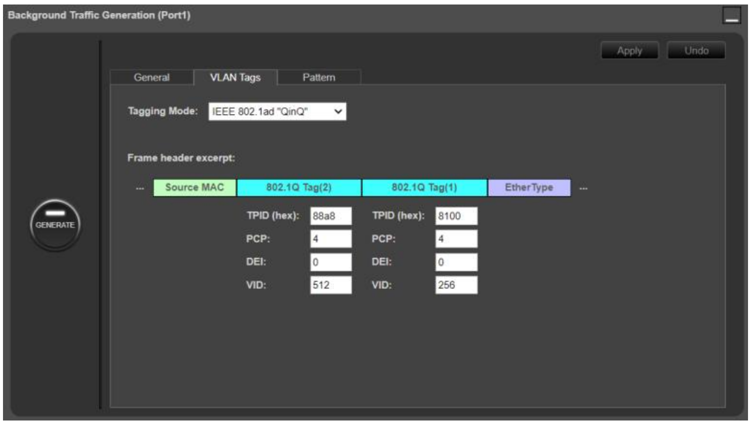
The measurement methodologies specified in ITU-T G.8273 Annex B include a requirement for traffic generation to introduce suitable loading on the ports of the DUT that carry the timing packets.

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.

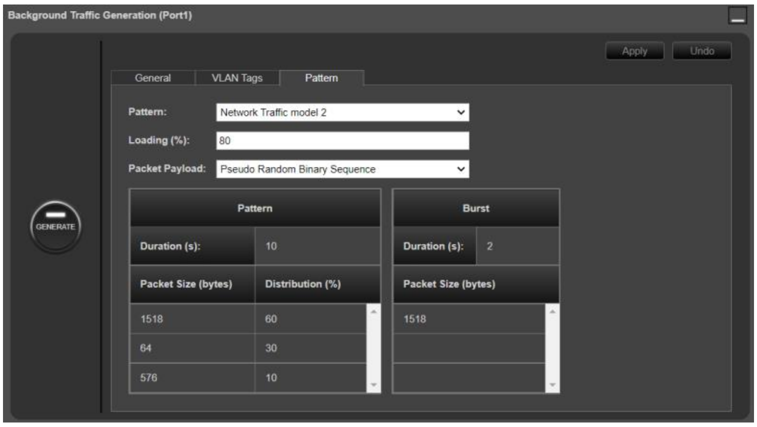
1. In the **Background Traffic Generation** app for the required Paragon-neo port, choose **General** and select the encapsulation, source and destination addresses for the generated traffic.



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

The noise generation is measured on PTP and 1PPS outputs of the DUT using multiple metrics. The table below summarizes the metrics and limits that apply to both the PTP and 1PPS 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.

The table in Appendix 1 at the end of this document includes some additional values for Class D clocks that have been proposed but have not been standardized.

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

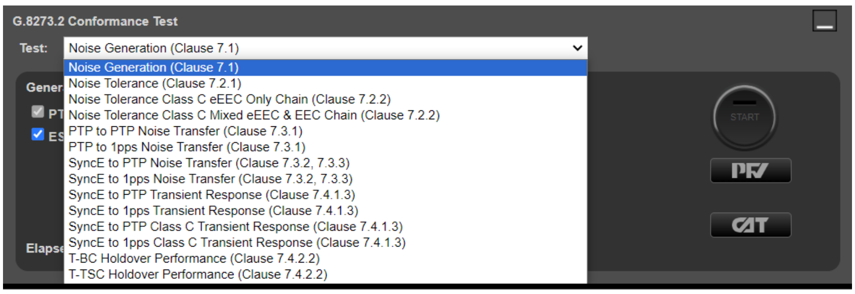
Notes:

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

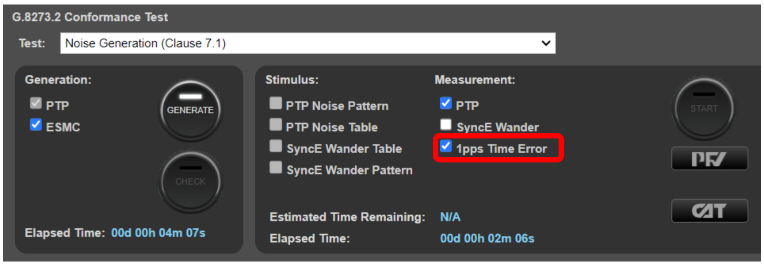
1. Confirm that the DUT is correctly connected to Paragon-neo and the settings within the **PTP emulation** app are appropriate for the current test scenario as described in Sections 3 and 4.
2. Configure the DUT test environment for either a constant or variable temperature test; guidelines for variable 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. If a 1PPS output is to be concurrently measured from the DUT, from the **Measurement** section of the **Conformance Test** app, check the **1pps Time Error** checkbox.

   Note: Verification by the 1PPS only is NOT recommended for Boundary Clock devices since it is the PTP flow that the downstream device will use.

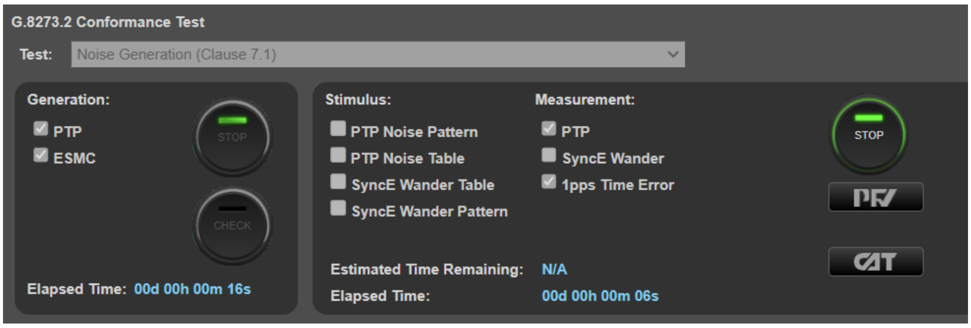


6. From the **Generation** section of the **Conformance Test** app, press **Generate**. This starts PTP and ESMC message generation allowing the DUT to stabilize.

   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.

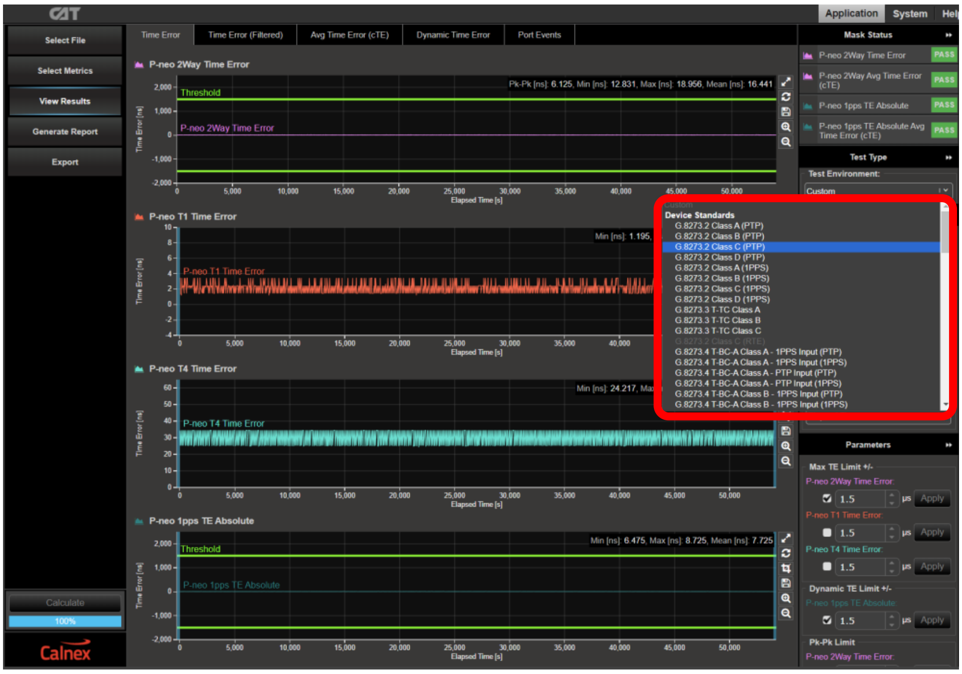
9. Follow the steps in the appropriate section (5.1 or 5.2) below depending on whether the test was under constant or variable temperature conditions. Additionally, options for further analysis are provided in section 5.3.

5.1 Constant Temperature Test Results analysis

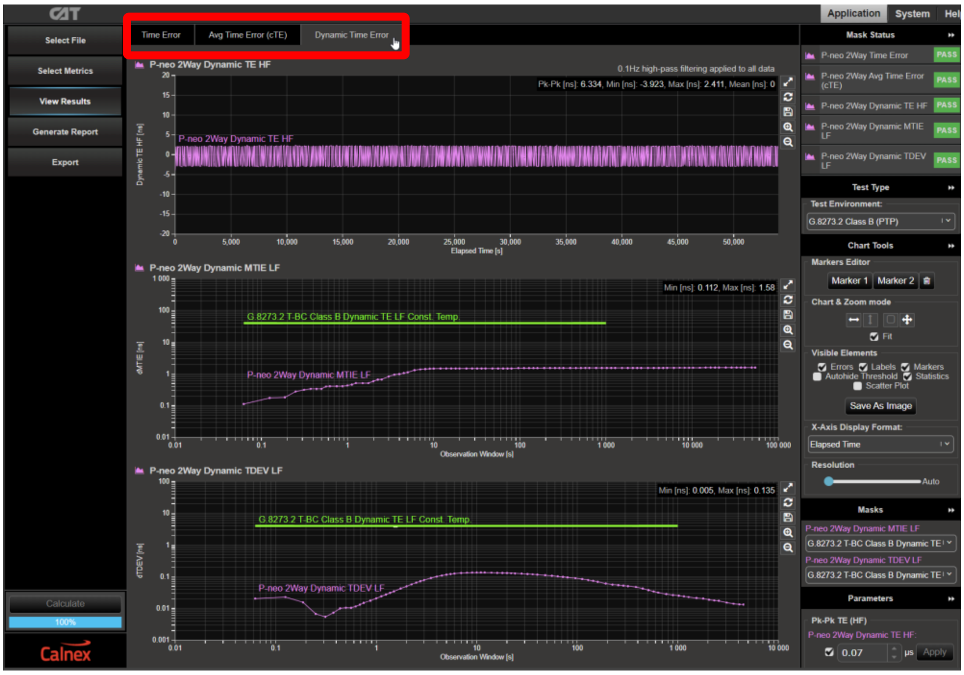
The steps in this section describe how to analyze the results of a test made under constant temperature conditions.

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.

   If both PTP and (optionally) 1PPS measurements have been completed, follow the steps below, including checking the Pass/Fail, then return to this step to set the environment for the other signal type.

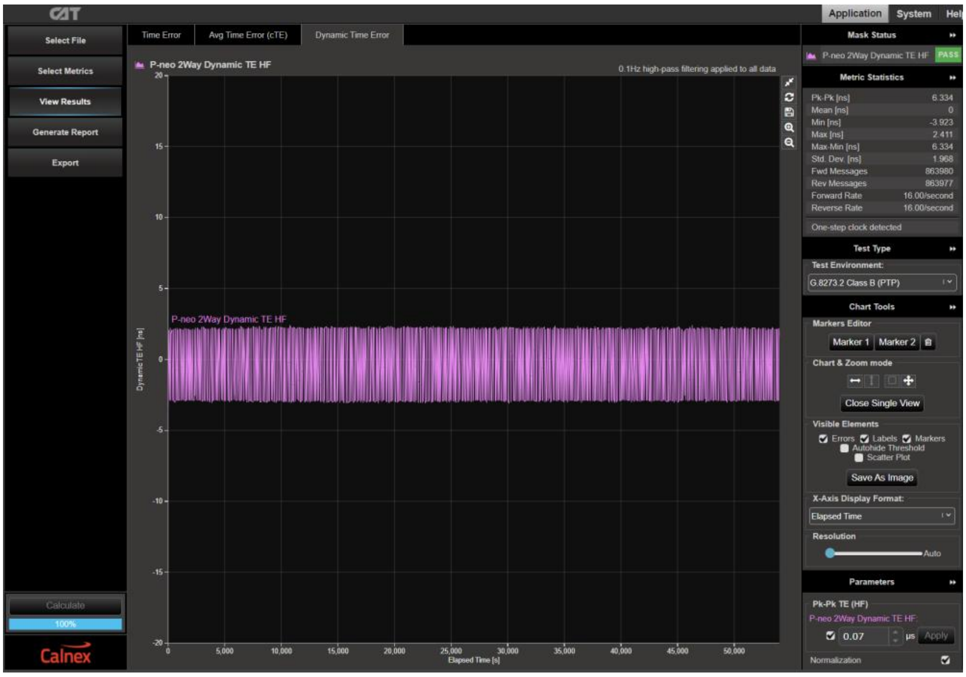


Navigate to the available metrics for the **Test Environment** by using the tabs at the top of the window.

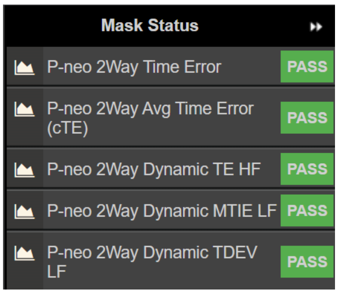


Clicking on the expand button at the top right of a plot will open the plot in a single view:

This will show the selected plot in Single View mode, which includes more detailed information on the right side of the screen:



2. The T-BC 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.



Further Analysis

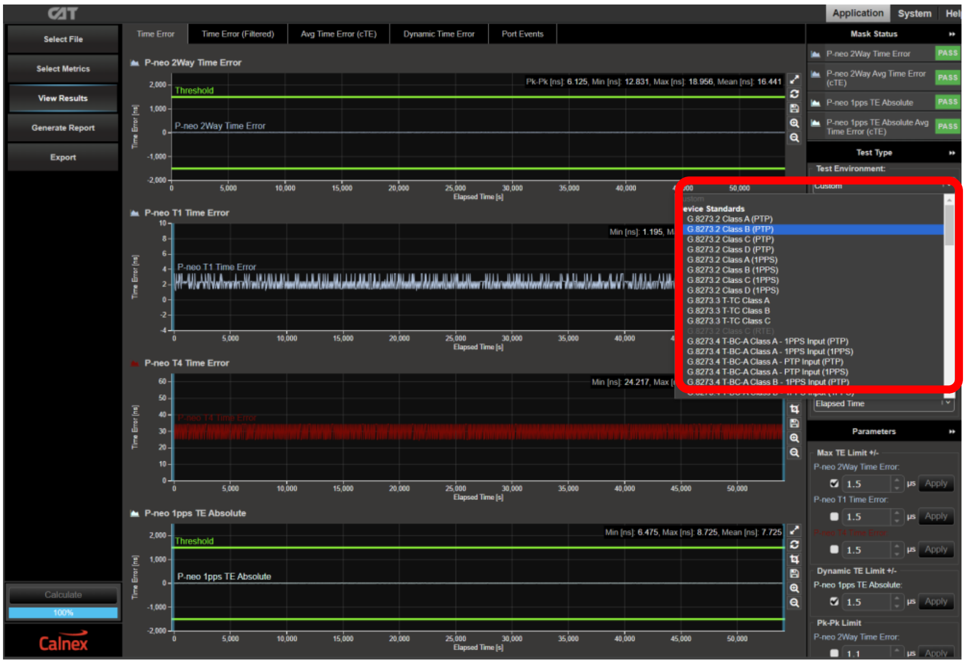
The table in Appendix 1 at the end of this document includes some additional values for Class D clocks that have been proposed but have not been standardized. These proposed limits can be applied to check device conformance; CAT includes the mask for G.8273.2 T-BC Provisional Class D Dynamic TE LF Const. Temp.

5.2 Variable Temperature Test Results Analysis

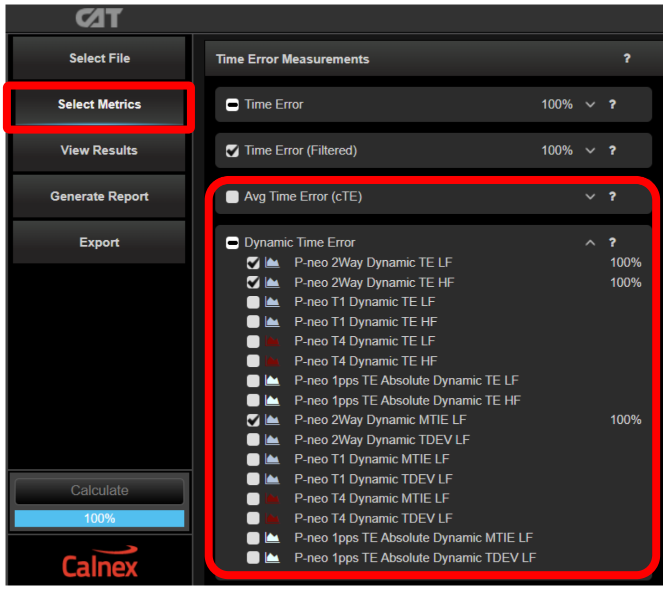
The steps in this section apply to a test made under variable temperature conditions. Guidelines for variable temperature testing are described in Appendix I of ITU-T G.8273.

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.

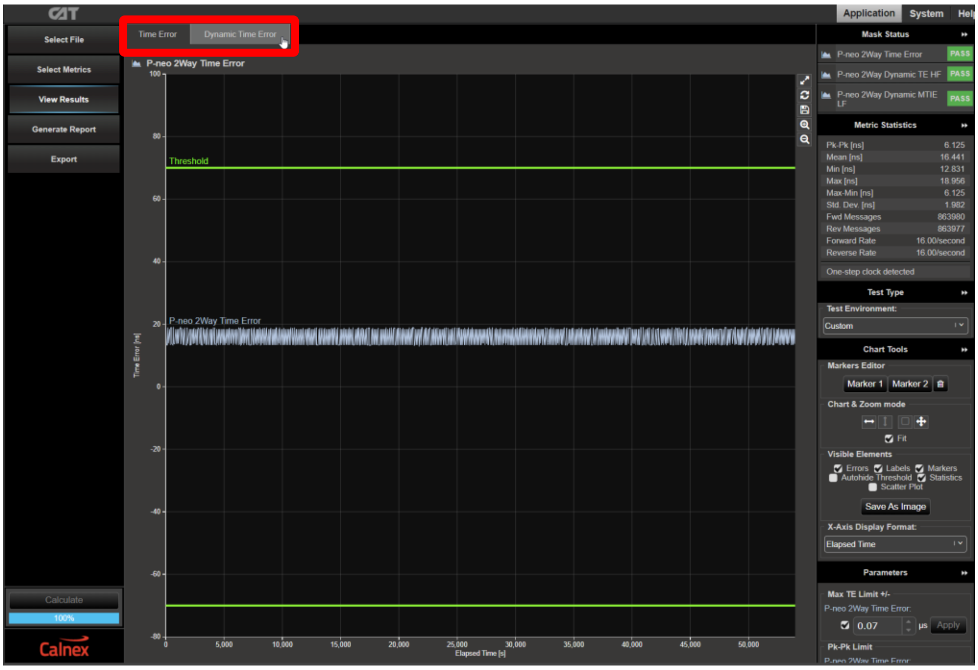
   If both PTP and (optionally) 1PPS measurements have been completed, follow the steps below, including checking the Pass/Fail, then return to this step to set the environment for the other signal type.



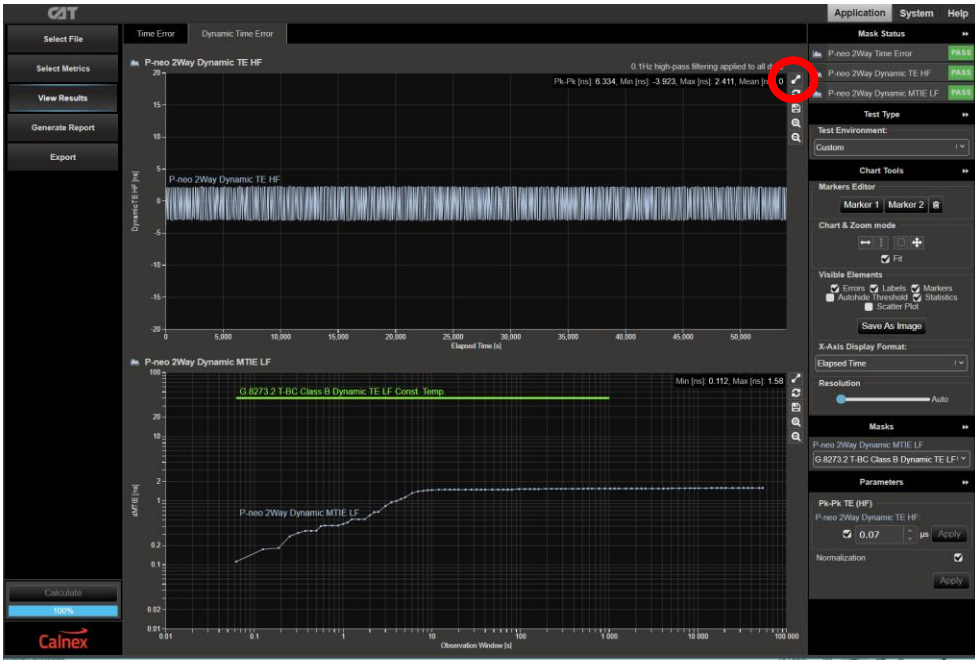
2. Click **Select Metrics** and uncheck the metrics for the **Avg Time Error (cTE)** and all the **TDEV** metrics in the **Dynamic Time Error** section. The unchecked metrics will be removed from the measurement results.



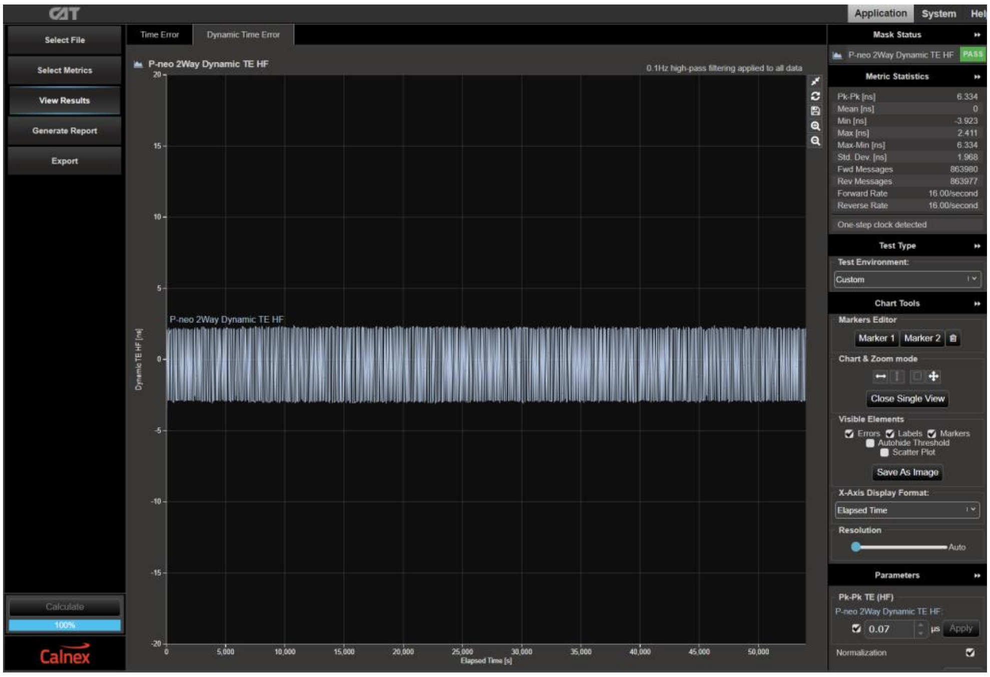
3. Select **View Results**, then navigate to the available metrics for the **Test Environment** by using the tabs at the top of the window.



Clicking on the expand button at the top right of a plot will open the plot in a single view:

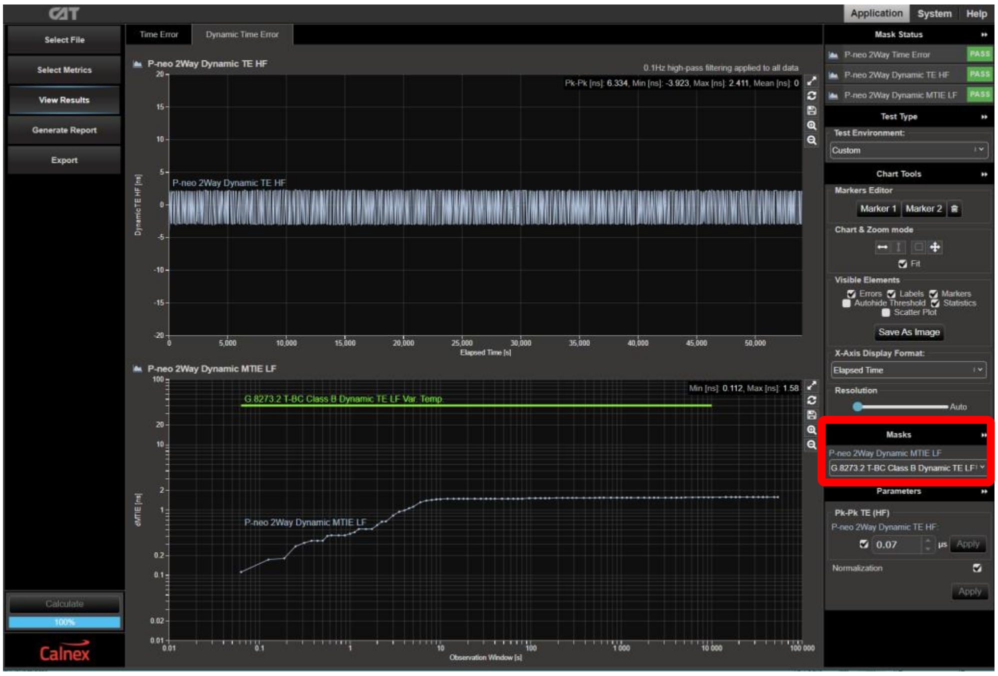


This will show the selected plot in Single View mode which includes more detailed information on the right side of the screen:

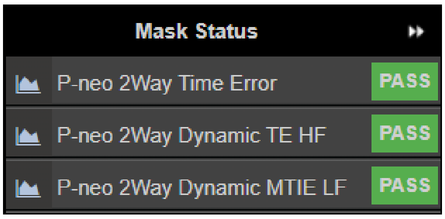


4. Navigate to the **Dynamic Time Error** tab and select the appropriate mask for the device class.

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.



5. The T-BC 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.

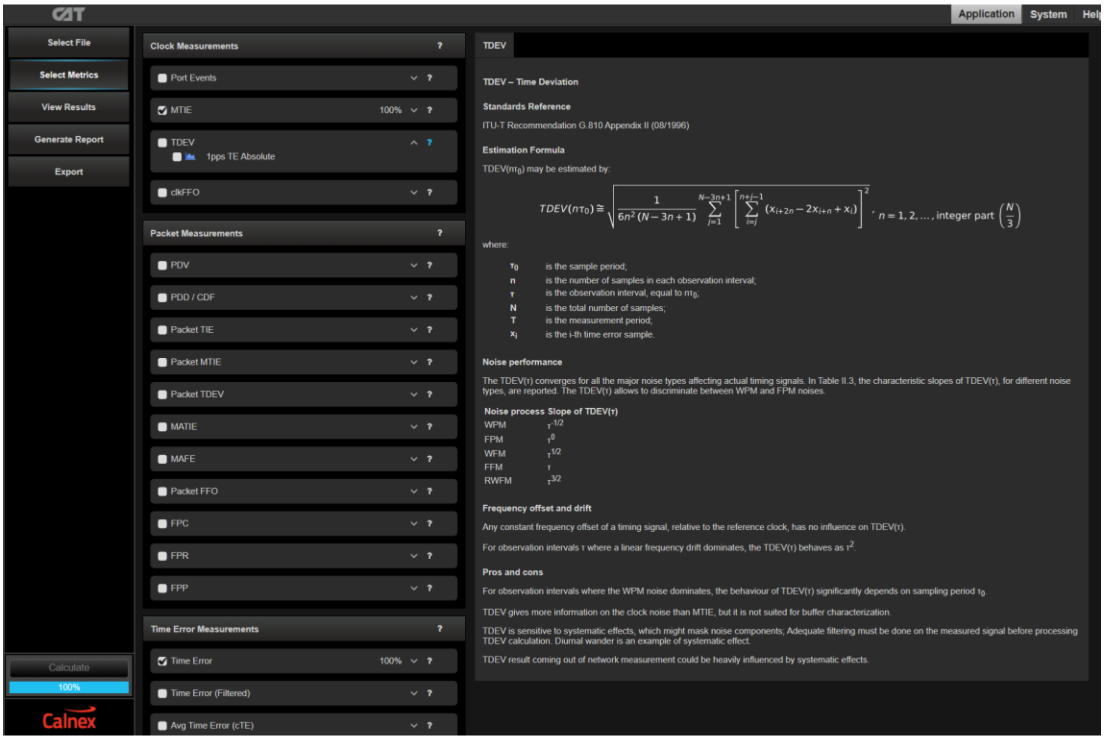


5.3 Further Analysis (optional)

For further analysis, select the **Time Error** tab for unfiltered Time Error results i.e. **2-way time error**, **T1 Time Error (forward)** and **T4 Time Error (reverse)** to further characterize the T-BC. These raw Time Error results containing both Constant and Dynamic Time Error may be useful as a troubleshooting aid.

Launching **PFV** will allow you to decode and display PTP field information in a new browser tab. If the PFV option is installed on the Paragon-neo unit, conformance checking to defined PTP profiles with pass/fail analysis is also possible. For further information please refer to the **PFV Getting Started Guide**.

The complete set of available metrics can be viewed by clicking **Select Metrics**. Each metric can be expanded by clicking on the "**v**" icon to the right of the metric name. Help is also available for each metric by clicking the "**?**" icon.



6 Relative Time Error Noise Generation – G.8273.2 Clause 7.1.4

Test Description

The Relative Time Error Noise Generation of a T-BC represents the difference in time error (noise) between two-phase and time outputs of a device when it has an ideal input reference packet timing signal and an ideal input reference frequency signal. The output types to test are PTP and 1PPS.

Ideally, all combinations of ports on a device should be tested. However, if this is not feasible then, where relevant, focus should be on testing ports that are most likely to have the largest timing offset between them. This could include ports that are controlled by different ASIC or FPGA modules that are either referenced to different oscillators or are in a separate physical chassis of a system.

The noise generation has two defined components: relative constant time error (cTE_R) and relative dynamic low-pass filtered noise generation (dTE_{RL}).

The current version of G.8273.2 (06/2023) defines this for only Class C T-BCs. Requirements for other classes of T-BC are for further study.

As per Section 2, a different physical test configuration is required for testing PTP vs. PTP/1PPS and 1PPS vs.1PPS Relative Time Error.

The Class C T-BC performance requirements are below.

DUT Class	Output Type	cTE_R	cTE_R Averaging	dTE_{RL} (MTIE)	MTIE Observation Interval (τ) [s]
Class C	1PPS	± 12ns	1000s	14ns	$1 \le \tau \le 1000$
	PTP (16 pkt/s)	± 12ns	1000s	14ns	$0.0625 \le \tau \le 1000$

These values apply to 1PPS, 1GbE, 10GbE, 25GbE, 40GbE and 100GbE interfaces. Values for other interfaces are for further study.

Measurement Process

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

   In the **PTP Emulation** app, ensure **Relative Time Error / 2 x TE** is the **Test Mode**. Note that in this mode, separate cable compensation values must be entered for Port 1 and Port 2.

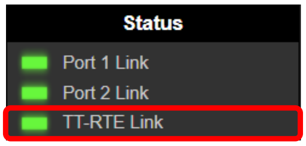
2. To test to the measurement methodology specified in ITU-T G.8273, ensure the **Background Traffic** app is configured as described in Section 4.5.

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

6.1 PTP vs. PTP/1PPS Relative Time Error, and for Two Simultaneous PTP Measurements

This section describes making PTP vs PTP Relative Time Error measurements. The same process can be used to run two PTP measurements in parallel, reducing device testing time if no Relative Time Error measurements are required.

1. If the Paragon-neo is the timeTransmitter for the DUT, confirm that the TT-RTE Link is showing as link up.



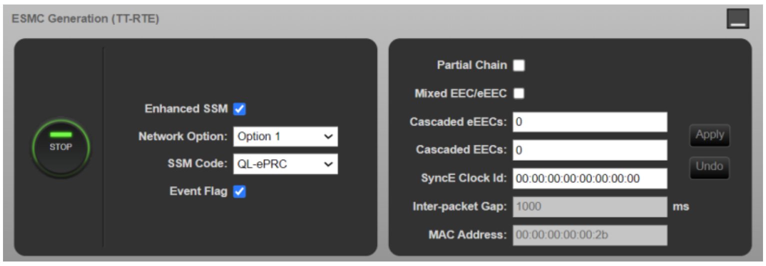
   Note: The RTE timeTransmitter Port (labelled Port 2 100M SFP on the instrument front panel, and TT-RTE in the **Setup Ports** screen in the GUI) runs at 1G and not 100M in Relative Time Error test mode.

2. If required, use the **TT Config** button to configure the PTP emulation settings to those appropriate for the DUT. Press **Generate TT** to start the PTP emulation for the timeTransmitter.

3. If required, use the **TR 1 Config** and **TR 2 Config** buttons to configure the PTP emulation settings to those appropriate for the DUT. Press **Generate TR-1** and **Generate TR-2** to start the PTP emulation on both timeReceiver ports**.**

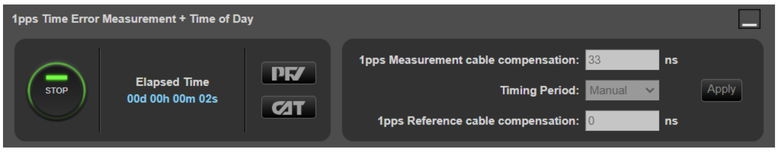
   Confirm that the PTP sessions are running correctly and that both timeReceivers connect to the required DUT timeTransmitter/PTP Port instance(s).

4. If the DUT requires a SyncE frequency reference, from the **ESMC Generation (TT-RTE)** app configure the options to ensure the DUT uses this signal as a reference. Press **Generate**.



5. Click on **Measure** then select **CAT to** launch the Calnex Analysis Tool and confirm that the DUTs timeReceiver PTP outputs are stable and ready to test.

6. In the **1pps Time Error Measurement + Time of Day** app, click on **Measure** then select **CAT** to launch the Calnex Analysis Tool and confirm that the DUTs 1PPS output is stable and ready to test.



7. Once you are confident that the DUT is locked and stable, **Stop** then **Start** all running measurements again and allow to run for at least 1000s.

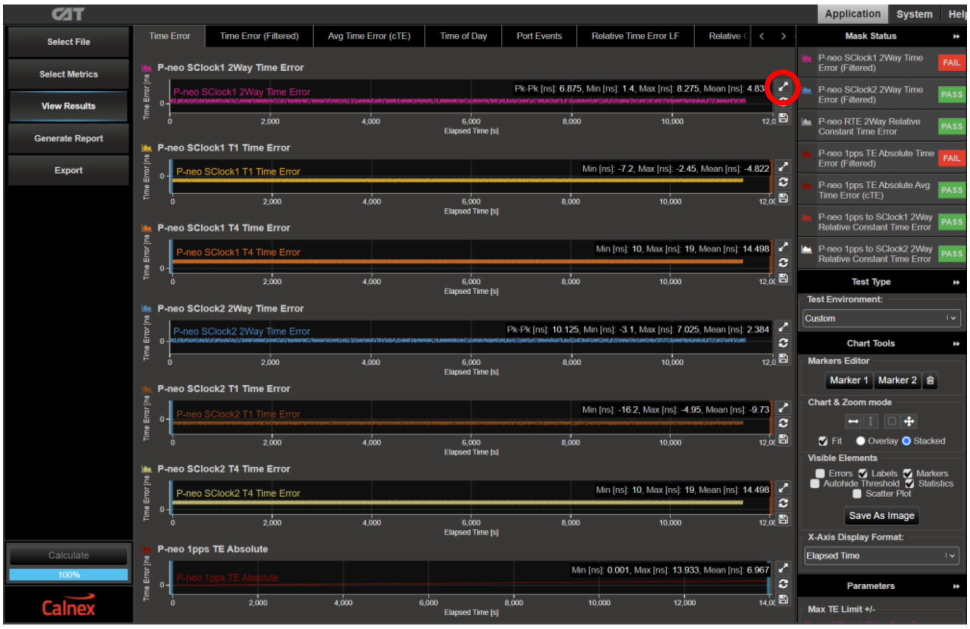
   If you are also measuring a 1PPS signal from the DUT, ensure that there is at least 1000s of concurrent (overlapping) time of the 1PPS measurement and any PTP measurements.

   The results for the measurements can either be viewed during a capture or after the capture has been stopped. If the difference between the **Mean[ns]** values for individual measurements is greater than 12ns then it is likely that the resultant Relative Time Error will not be within the required limit for G.8273.2 conformance.

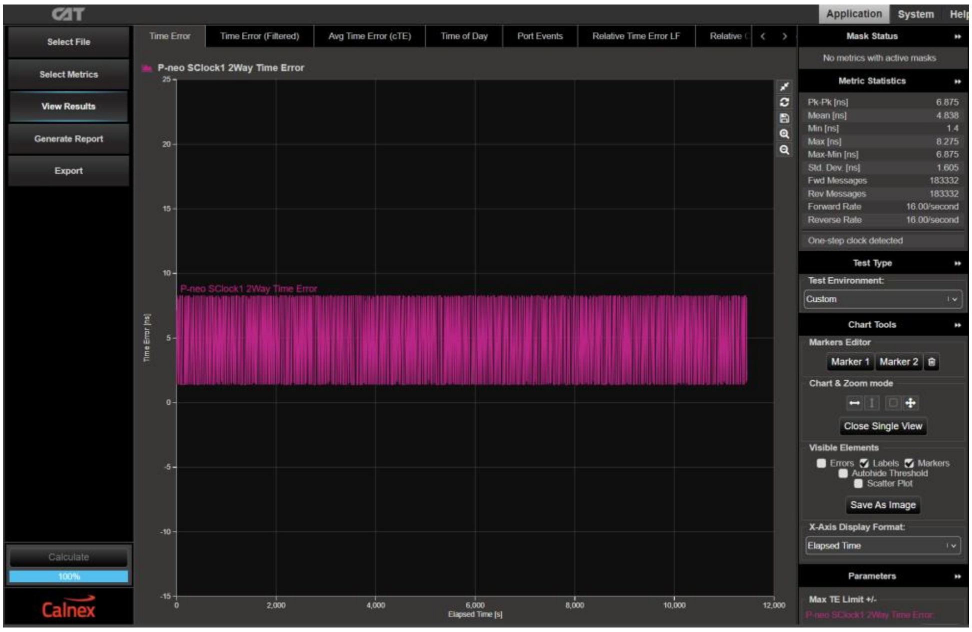
8. Click the **CAT** button to open CAT in a new tab to observe the measurements. The **Time Error** metrics show the individual measurements from the two Paragon-neo timeReceiver PTP instances and the 1PPS measurement if configured.

   These metrics can be used to verify the configuration and performance of the associated individual DUT 1PPS and timeTransmitter/PTP Port instances. These metrics show each individual measurement – they are not the Relative Time Error metrics which are detailed in the next section.

Individual plots can be displayed by clicking on the highlighted area in the display below:



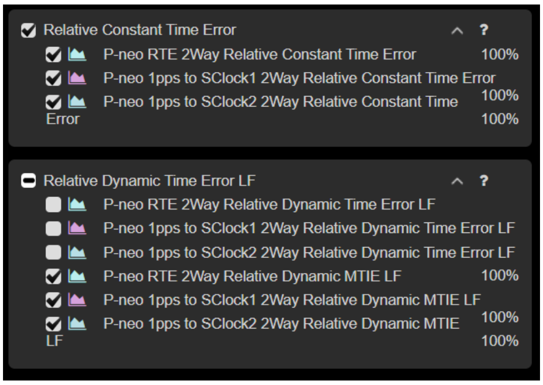
This will show the selected plot in Single View mode, which includes more detailed information on the right side of the screen:



Results Analysis

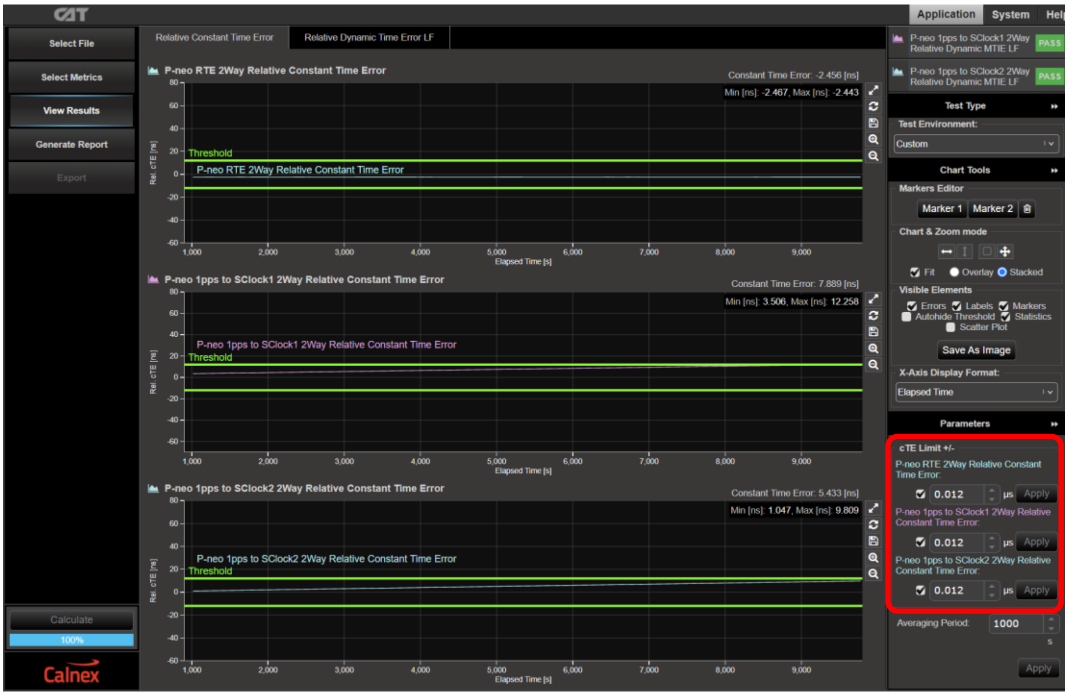
1. In **CAT**, click **Select Metrics** and ensure the required **Relative Constant Time Error** and **Relative Dynamic Time Error MTIE LF** plots are checked, then press **Calculate.** The available metrics will depend on the configured measurements.

   All other metrics can be unchecked if required to limit conformance checking to the relevant metrics only.

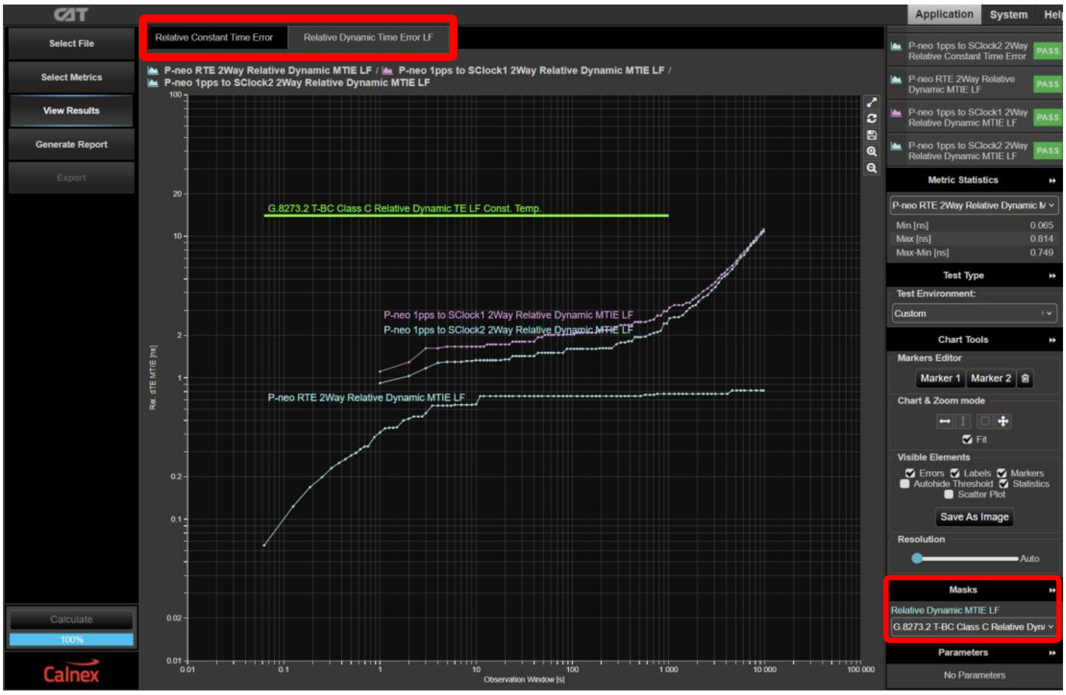


2. Select **View Results** then select the **Relative Constant Time Error** tab. If not already configured, set the **cTE Limit** to the following, as per the G.8273.2 requirement for each available measurement, and ensure that the checkbox is set to checked to apply the threshold.

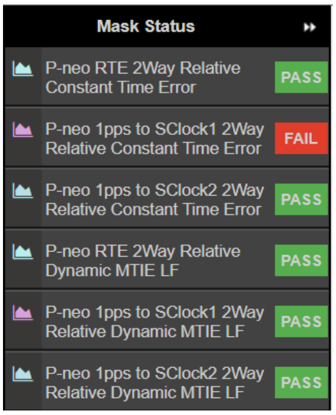
DUT Class	cTE_R	cTE Limit (µs)
Class C	± 12ns	0.012



3. Select the **Relative Constant Time Error LF** tab. Apply the **G.8273.2 T-BC Class C Relative Dynamic TE LF Const. Temp.** mask to the **Relative Dynamic MTIE LF** metric.



6. The T-BC 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.



6.2 1PPS vs. 1PPS Relative Time Error

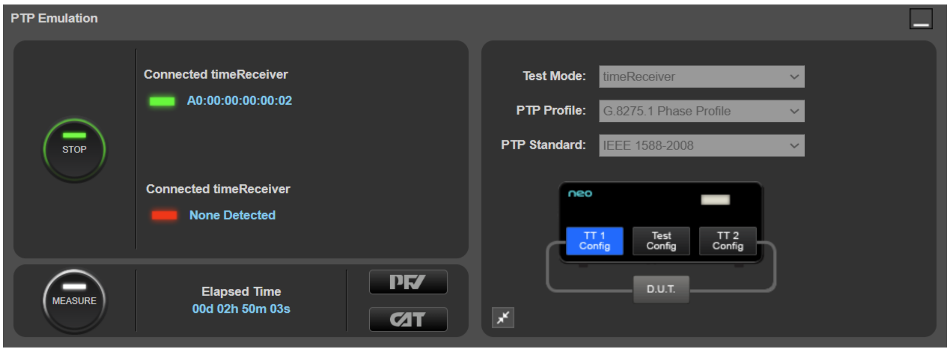
This section describes making 1PPS vs 1PPS Relative Time Error measurements. The theory of operation is that one of the 1PPS outputs from the DUT is configured as the reference signal to Paragon-neo and the other is the measured signal; the resultant measurement is the Relative Time Error between those two signals.

1. Set up Paragon-neo for the 1PPS Relative Time Error Test as described in described in Section 3.

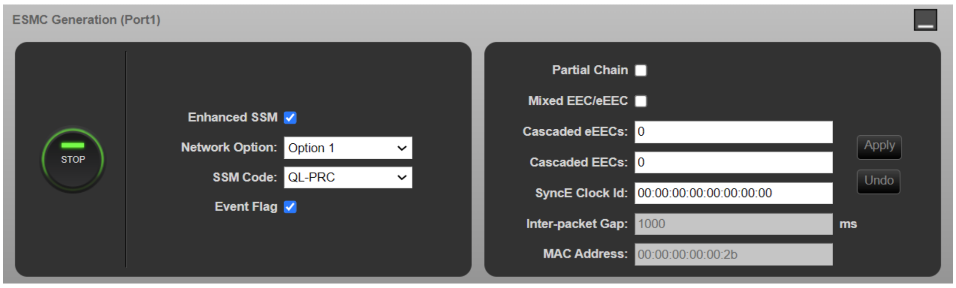
2. Within the **PTP Emulation** app, from the **Test Mode** menu select **timeReceiver**. This will cause Paragon-neo to emulate a timeTransmitter instance which will be used as the DUT PTP reference. Ensure that the **PTP Profile** is set to **G.8275.1 Phase Profile**.

3. Select **Test Config** and confirm that the settings are appropriate for the current configuration.

4. From the **PTP Emulation** app**,** press **Generate** and confirm that the PTP session runs correctly with the DUT timeReceiver being detected. Only a single connection to the timeReceiver is required for this test.



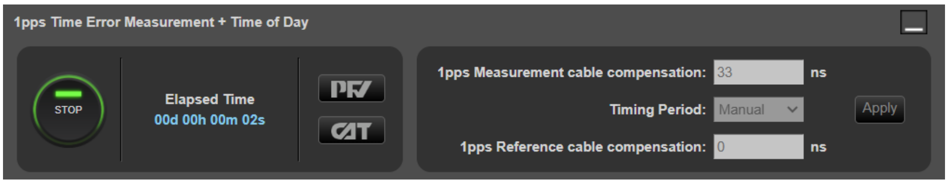
5. If the DUT requires a SyncE frequency reference, from the **ESMC Generation (Port 1)** app, select an appropriate SSM Code value to ensure the DUT uses this signal as a reference, then press **Generate**.



6. Scroll down to the **1PPS Time Error Measurement + ToD** app and start the measurement.

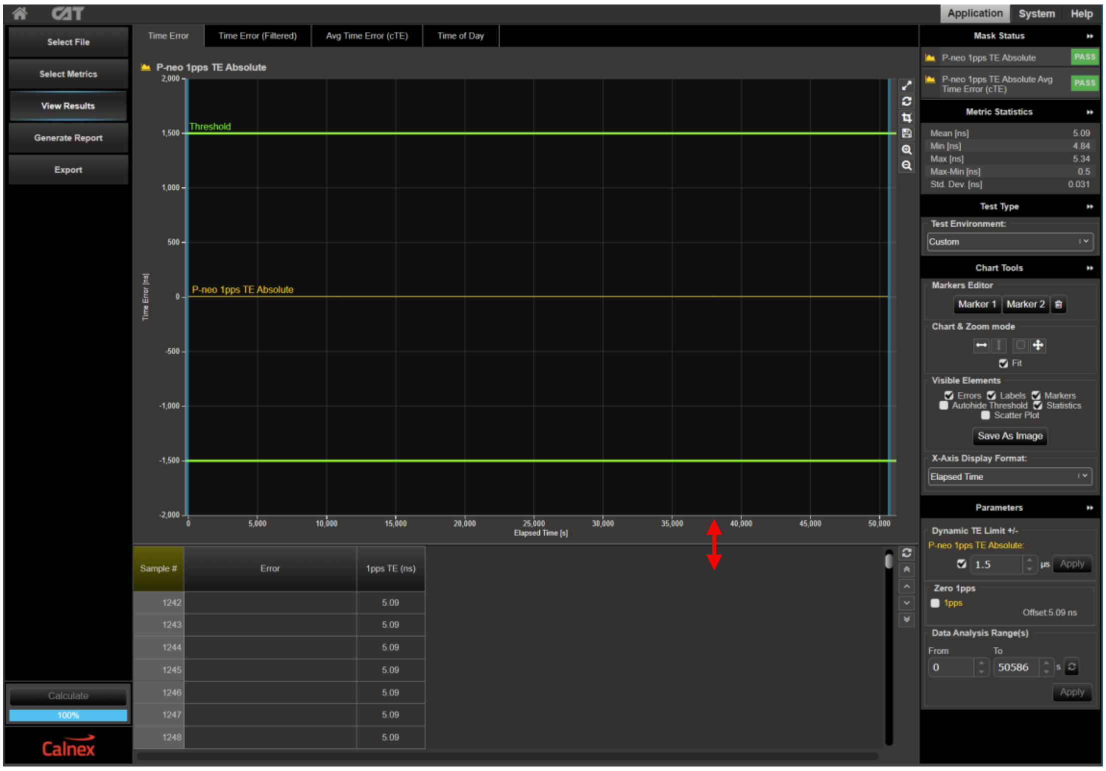
   Select **CAT** to launch the Calnex Analysis Tool and confirm that the DUTs 1PPS outputs are stable and ready to test.

   Note: As the 1PPS Reference and Measurement signals are both coming from the DUT, any instability may be associated with either signal, or both.



7. Once you are confident that the DUT is locked and stable, **Stop** then **Start** the 1PPS measurement. To view the results in real-time, click the **CAT** button and observe the metrics in another CAT tab. Allow the measurement to run for at least 1000s.

8. Open an instance of **CAT** to display **Time Error** metrics; this will contain the **P-neo 1pps TE Absolute metric**. The arrow below shows the separator for the **1PPS Samples Table** which can be moved to expand the plot area.

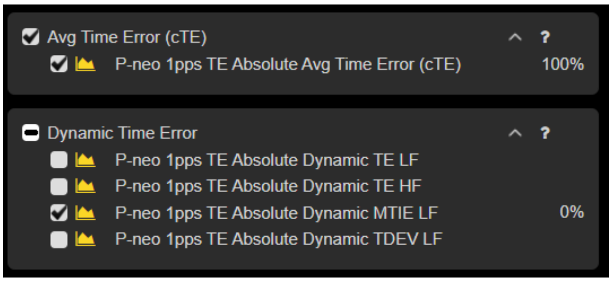


Results Analysis

Note: In this test configuration CAT doesn't include explicit cTE$_R$ or dTE$_{RL}$ metrics, the relative ($_R$) component is implemented by the test setup using the Reference and Measurement inputs which implicitly makes a relative measurement between these two inputs.

1. In **CAT**, click **Select Metrics** and ensure the **P-neo 1pps TE Absolute Avg Time Error (cTE)** and **P-neo 1pps TE Absolute Dynamic MTIE LF** plots are checked then press **Calculate.**

   All other metrics can be unchecked if required to limit conformance checking to the relevant metrics only.

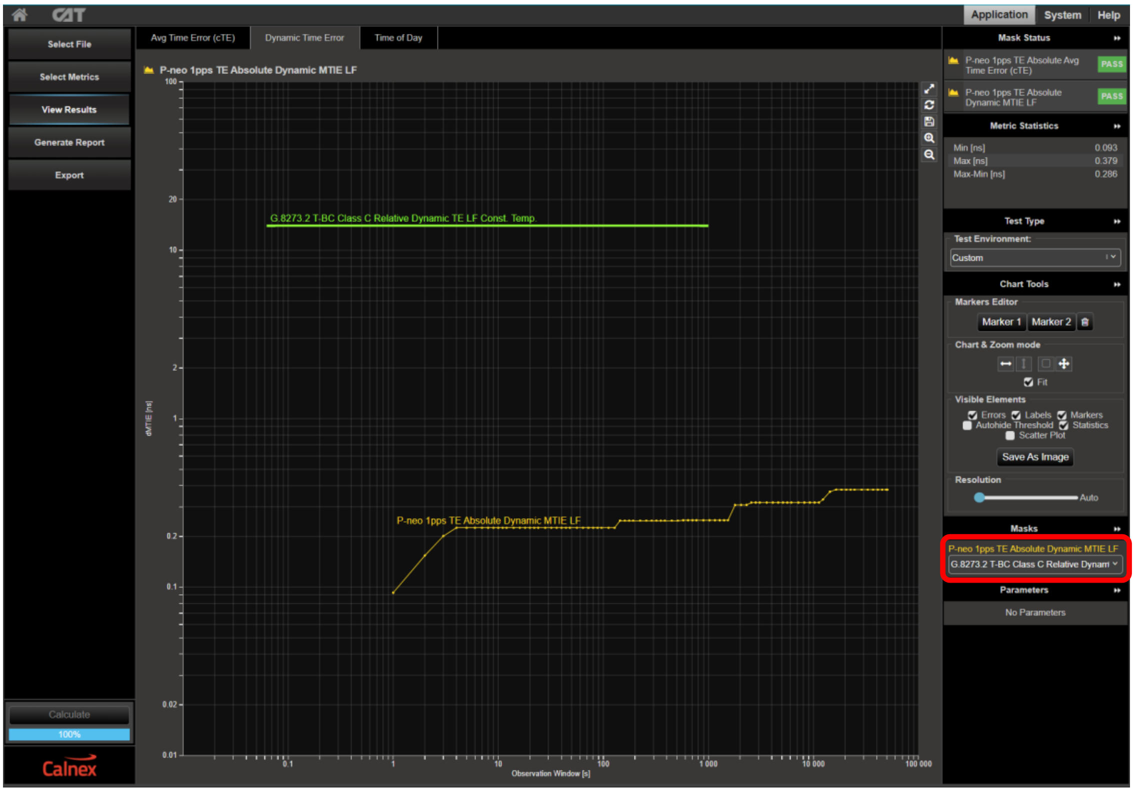


2. Select **View Results** then select the **Avg Time Error (cTE)** metric tab – in this test process, this represents the cTE$_R$ metric. Set the **cTE Limit** to the following, as per the G.8273.2 requirement, and ensure that the checkbox is set to checked to apply the threshold.

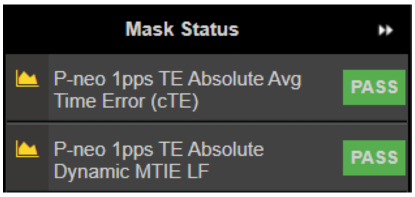
DUT Class	cTE$_R$	cTE Limit (µs)
Class C	± 12ns	0.012

3. Select the **Dynamic Time Error** tab to display the filtered Dynamic Time Error results. These results have been filtered using a first-order low-pass measurement filter with a bandwidth of 0.1Hz.

   Apply the **G.8273.2 T-BC Class C Relative Dynamic TE LF Const. Temp.** mask to the **P-neo 1pps Absolute Dynamic MTIE LF** metric.



7. The T-BC 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.



7 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-BC/T-TSC during a noise tolerance test. This is because the T-BC/T-TSC is a node within a chain. The noise accumulation through the chain is governed by the noise generation of the clock, and the network limits provide the overall limit on the performance of the chain. 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:

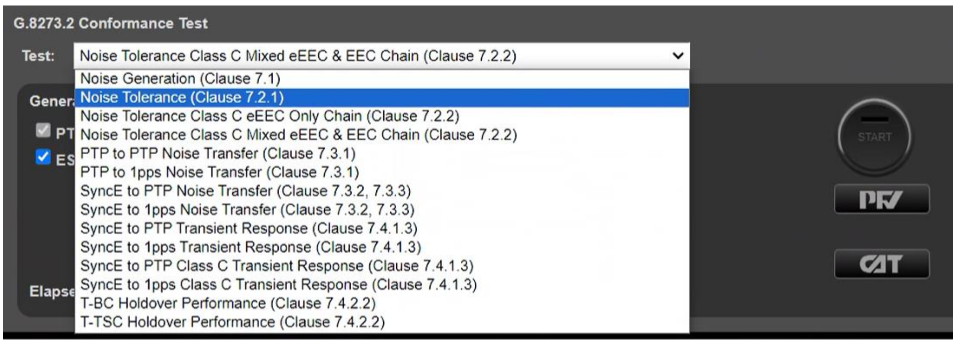
1. **Clause 9.1 (Level 1)** specifies tolerance requirements for enhanced equipment clocks that are used in reference chains containing enhanced synchronous equipment clocks (eEECs) only; this level is lower (tolerates less noise) than Level 2.
2. **Clause 9.2 (Level 2)** specifies tolerance requirements 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.

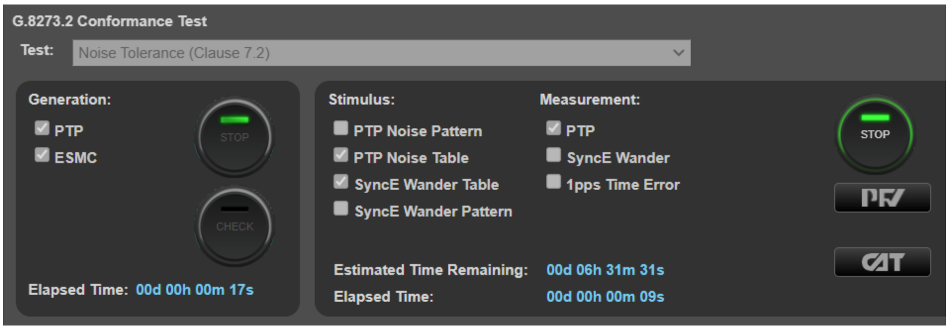
   For the greatest utility within a network, a Class C clock should be able to tolerate mixed chain (G.8262 / G.8262.1 Level 2) noise.



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 a **2WayTE 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 simultaneous PTP measurement is run by Paragon-neo during this test, indication of DUT lock can be determined by viewing the Time Error performance in CAT. in addition, the timing behavior of the DUT under the tolerance conditions can be further analyzed.

Furthermore, launching **PFV** will allow you to decode and display PTP field information in a new browser tab. If the PFV option is installed on the Paragon-neo unit, conformance checking to defined PTP profiles with pass/fail analysis is also possible. For further information please see **PFV Getting Started Guide**.

8 Noise Transfer – G.8273.2 Clause 7.3

Test Description

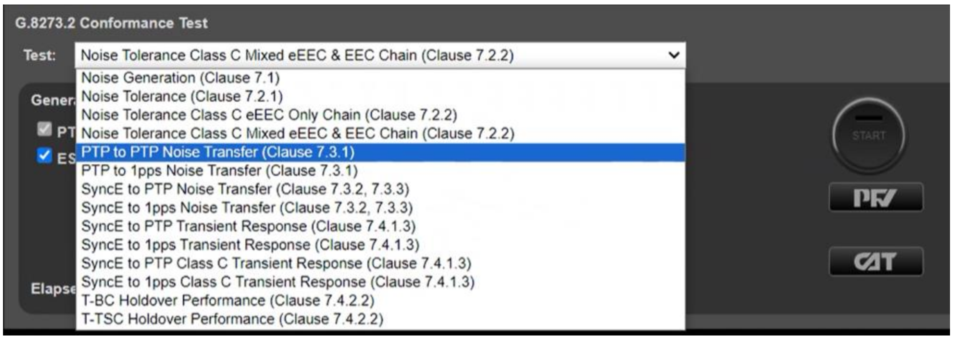
This test measures how Time Error on the input is transferred to the output.

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.

8.1 PTP to PTP Transfer (Clause 7.3.1)

1. From the **Test:** drop-down menu, select **PTP to PTP 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 **2WayTE 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 measurement.
4. PTP Noise (Time Error) is applied as per G.8273.2 Amendment 1 (Appendix VI).

   A least-squares filter technique as suggested in Amendment 1 is applied to the PTP signal to be measured. This technique addresses potential measurement uncertainty due to noise on the packet interface and the intrinsic noise generation of the T-BC.

   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

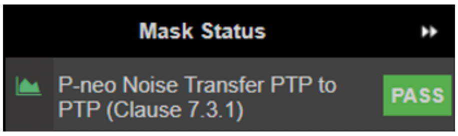
1. During or after the test, CAT can be launched to view the results – complete PTP-PTP transfer results are available in the **G.8273.2 Noise Transfer (Clause 7.3)** tab.

   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.

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.

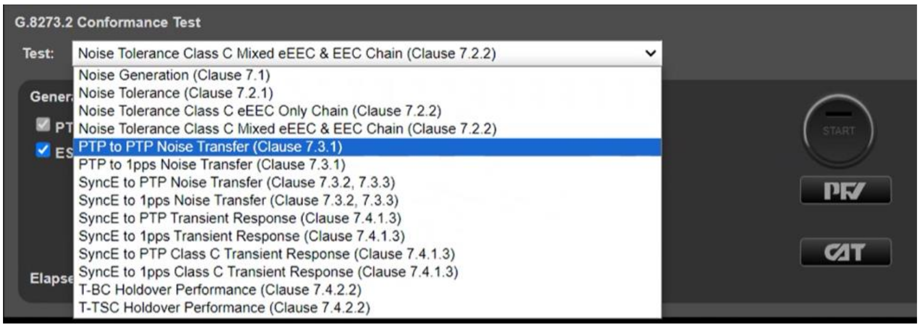
   Note that the pk-pk limits as defined in G.8273.2 are defined as a value *+N* to account for added noise generation of the DUT. The value of ***N* = 10ns** has been selected for the pass/fail limits as this provides the balance between the ability to measure accurately and give confidence that the DUT 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

3. The T-BC 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.



8.2 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.

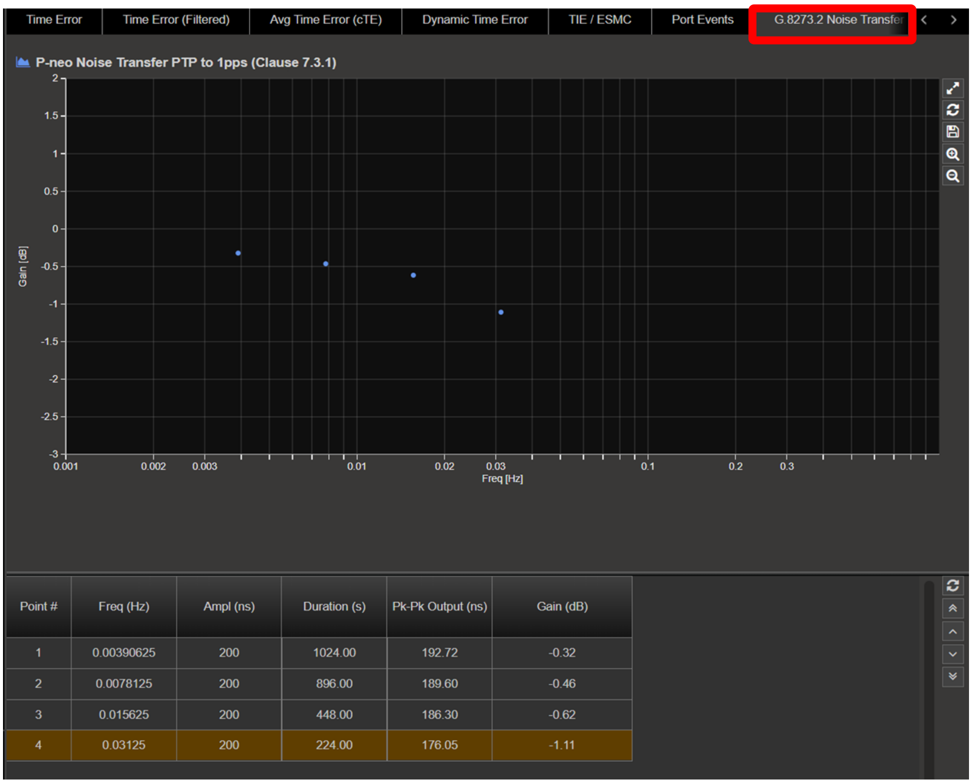
   PTP Noise (Time Error) is applied as per G.8273.2 Amendment 1 (Appendix VI).

   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

1. 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.

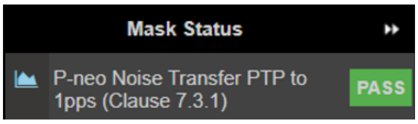
   A Bode plot is displayed along with a table of applied stimulus vs. gain. If a test step is still underway, this will be highlighted in orange on the table.



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.

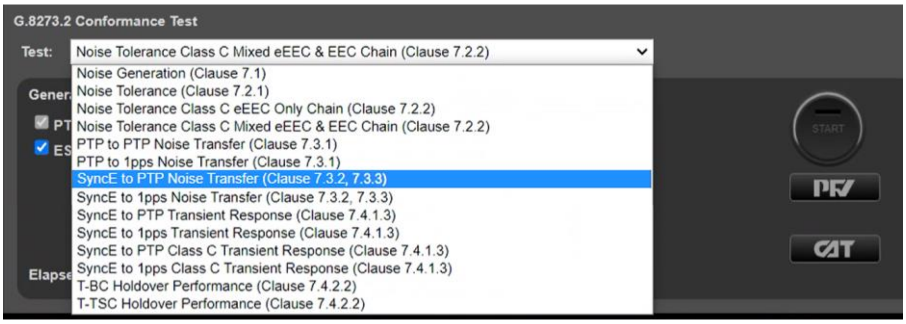
Note that the pk-pk limits as defined in G.8273.2 are defined as a value *+N* to account for added noise generation of the DUT. The value of ***N* = 10ns** has been selected for the pass/fail limits as this provides the balance between the ability to measure accurately and give confidence that the DUT 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

3. The T-BC 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.



8.3 SyncE to PTP Transfer (Clause 7.3.2, 7.3.3)

1. From the **Test:** drop-down menu, select **SyncE to PTP Noise Transfer (Clause 7.3.2, 7.3.3).**



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 **2WayTE 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 PTP measurement.

   PTP Noise (Time Error) is applied as per G.8273.2 Amendment 1 (Appendix VI).

   A least-squares filter technique as suggested in Amendment 1 is applied to the PTP signal to be measured. This technique addresses potential measurement uncertainty due to noise on the packet interface and the intrinsic noise generation of the T-BC).

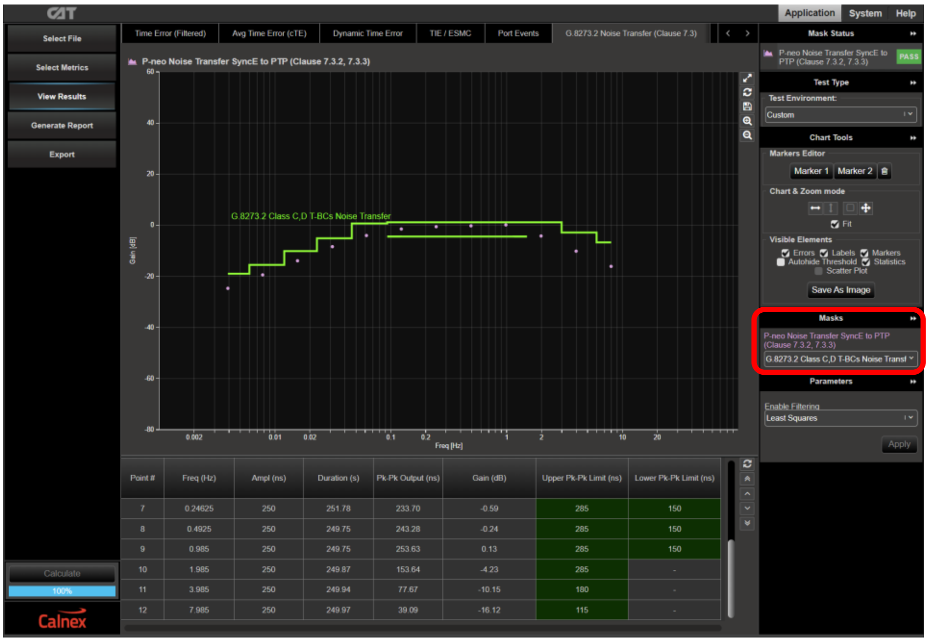
   For more information on the test considerations and the approach to test in the ITU-T recommendation, please see the Calnex application note **Time Error Transfer for BCs**.

Results Analysis

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.

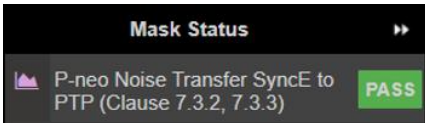
   A Bode plot is displayed along with a table of applied stimulus vs. gain. If a test step is still underway, this will be highlighted in orange on the table.

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.



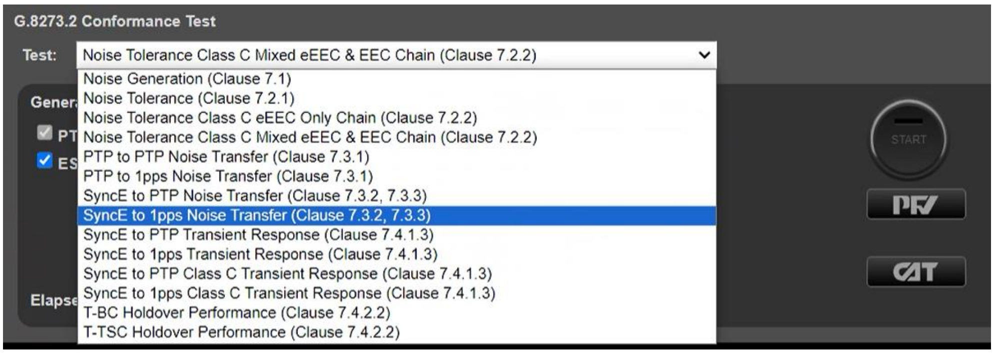
Note that the pk-pk limits as defined in G.8273.2 are defined as a value *+N* to account for added noise generation of the DUT. The value of ***N* = 25ns** has been selected for the pass/fail limits as this provides the balance between the ability to measure accurately and give confidence that the DUT 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-BC 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.



8.4 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).**



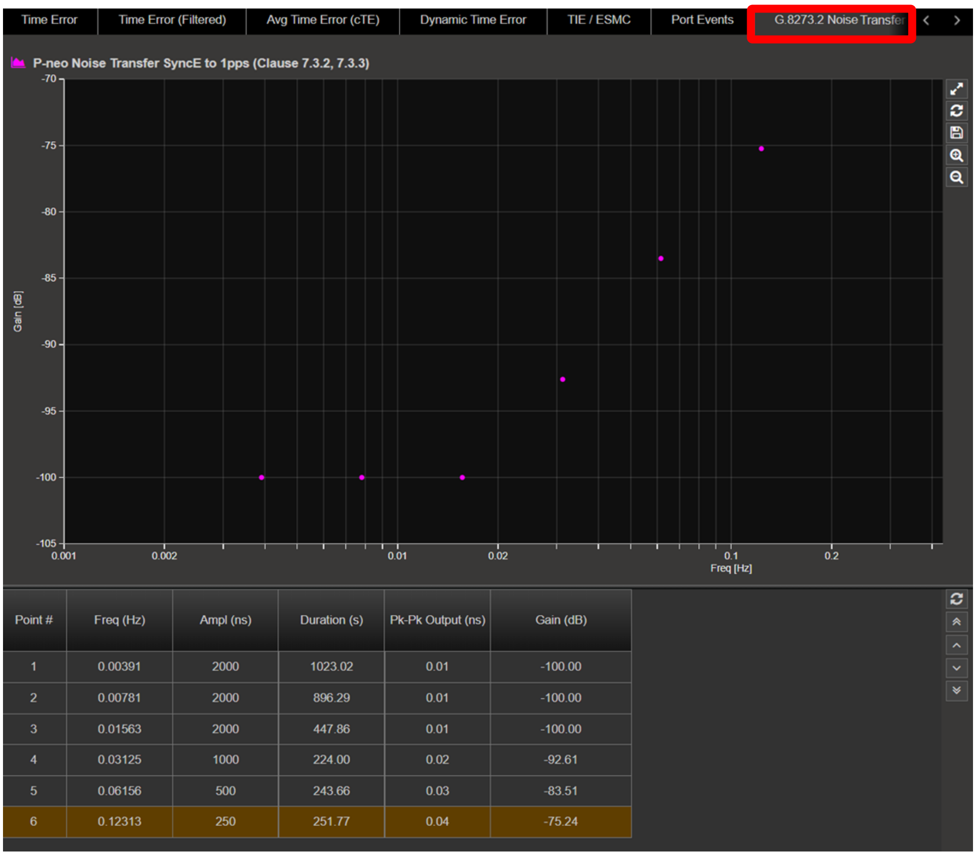
2. From the **Generation** section of the **Conformance Test** app, press **Generate.** This starts PTP and ESMC message generation allowing the DUT to stabilize. Pressing **Check** will open the CAT in a new tab allowing you to check current timing performance. In this case, you should wait for a **1PPS 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.



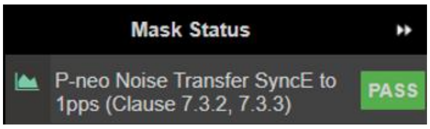
Point #	Freq (Hz)	Ampl (ns)	Duration (s)	Pk-Pk Output (ns)	Gain (dB)
1	0.00391	2000	1023.02	0.01	-100.00
2	0.00781	2000	896.29	0.01	-100.00
3	0.01563	2000	447.86	0.01	-100.00
4	0.03125	1000	224.00	0.02	-92.61
5	0.06156	500	243.66	0.03	-83.51
6	0.12313	250	251.77	0.04	-75.24

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.

Point #	Freq (Hz)	Ampl (ns)	Duration (s)	Pk-Pk Output (ns)	Gain (dB)	Upper Pk-Pk Limit (ns)	Lower Pk-Pk Limit (ns)
7	0.24625	250	251.78	251.71	0.06	285	150
8	0.4925	250	249.75	263.95	0.47	285	150
9	0.985	250	249.75	255.65	0.19	285	150
10	1.985	250	249.87	222.26	-1.02	285	-
11	3.985	250	249.94	172.19	-3.24	180	-
12	7.985	250	249.97	88.32	-9.04	115	-

   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-BC 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.



9 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-BC can generate a large transient in the T-BC input, therefore a T-BC 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-BC 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-BC 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-BC Classes A and B** in the event of a transient on the SyncE input:

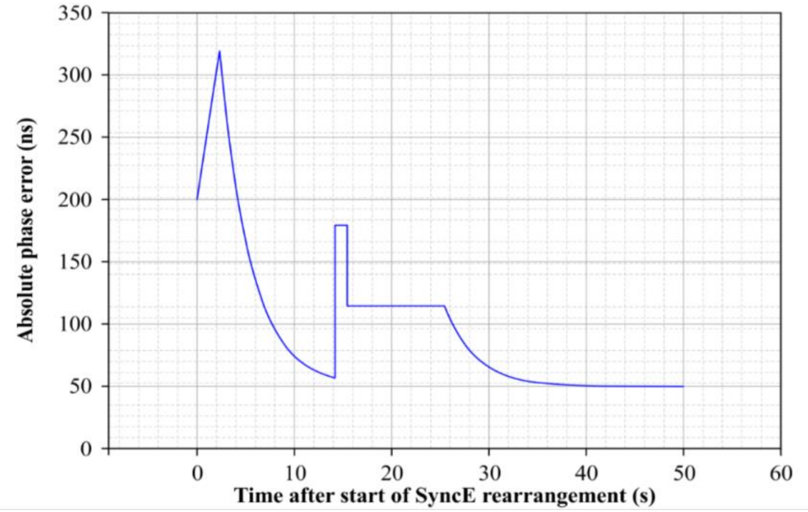


Figure B.1 from G.8273.2 Annex B – Phase error mask during a physical layer transient

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).

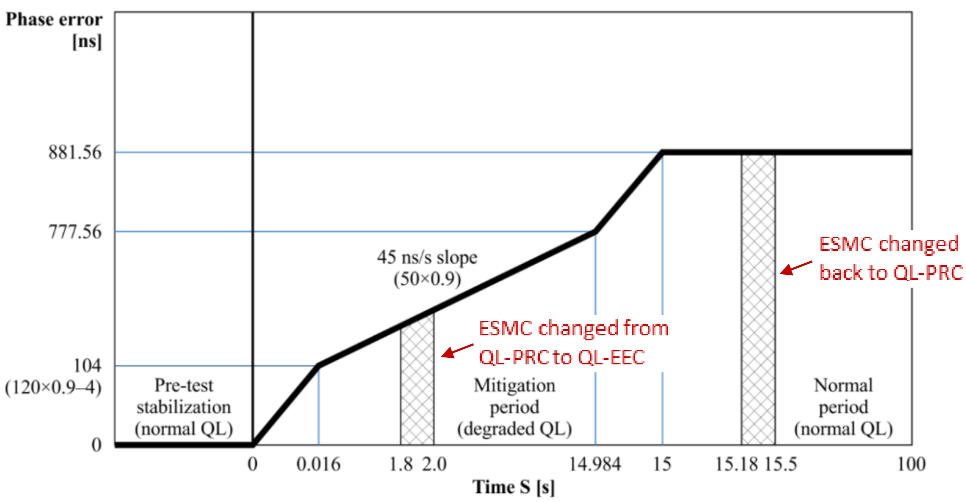


Fig. III.2 from G.8273 Appendix III – SyncE Transient Input Pattern

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

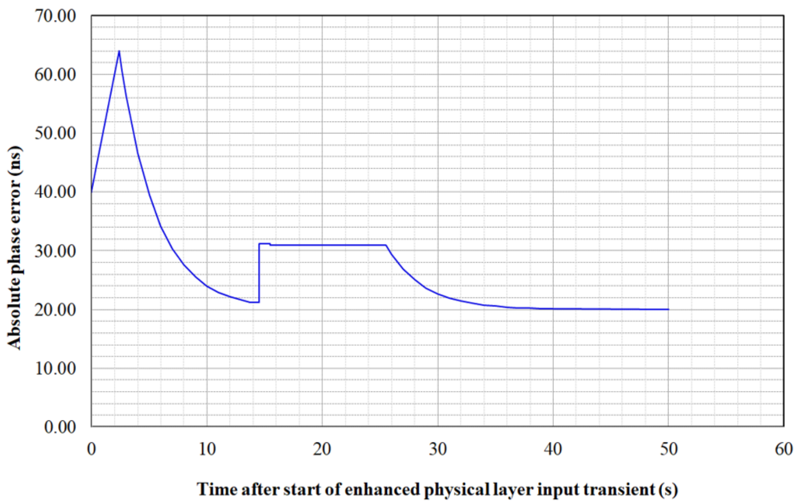


Figure C.1 from G.8273.2 Annex C – Phase error mask during an enhanced physical layer transient

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).

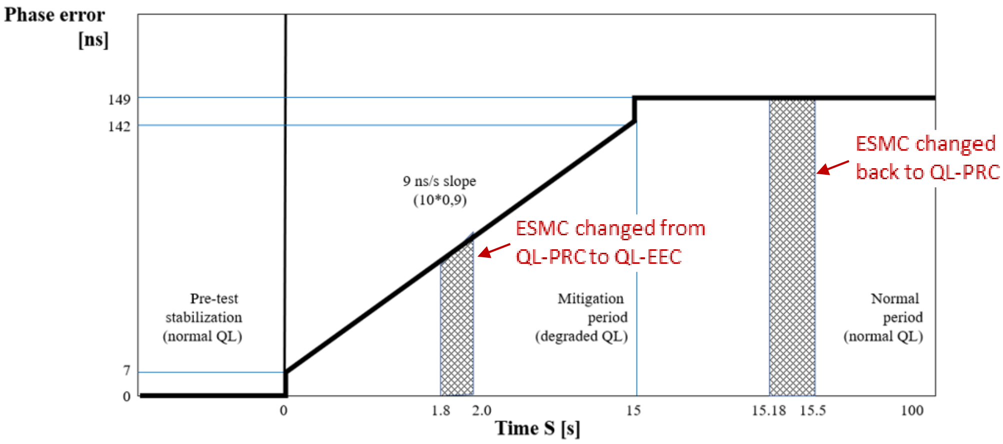


Figure III.3 –Test Case 1 enhanced synchronous equipment clock (e.g., eSyncE) transient input pattern

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

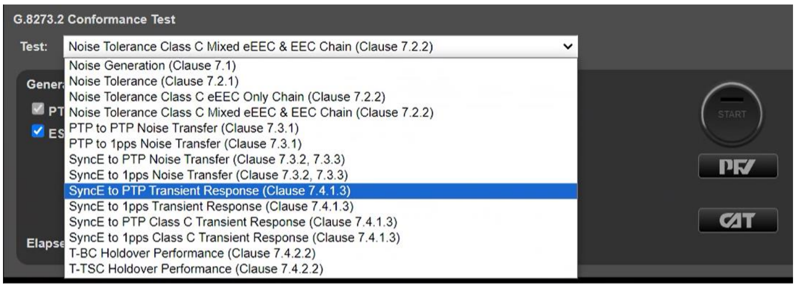
Measurement Process

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.

9.1 SyncE to PTP 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 PTP Transient Response (Clause 7.4.1.3)**
- For **Class C** conformance select: **SyncE to PTP 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 **2WayTE measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.

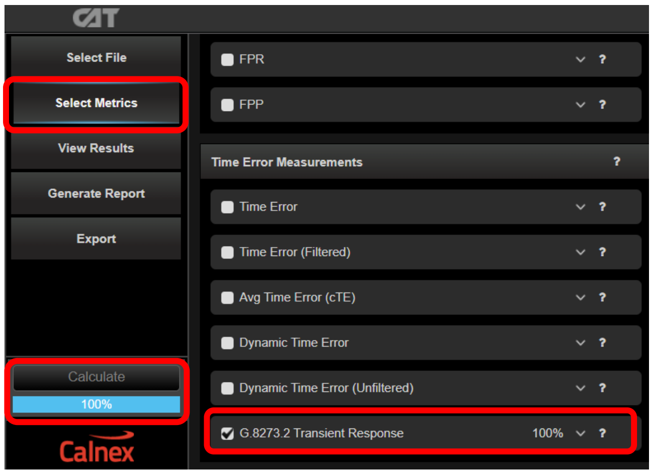
3. Once the DUT is stable, in the **Stimulus/Measurement** section, press **Start** to run the prescribed SyncE wander and ESMC state change stimulus and simultaneous PTP measurement.

   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

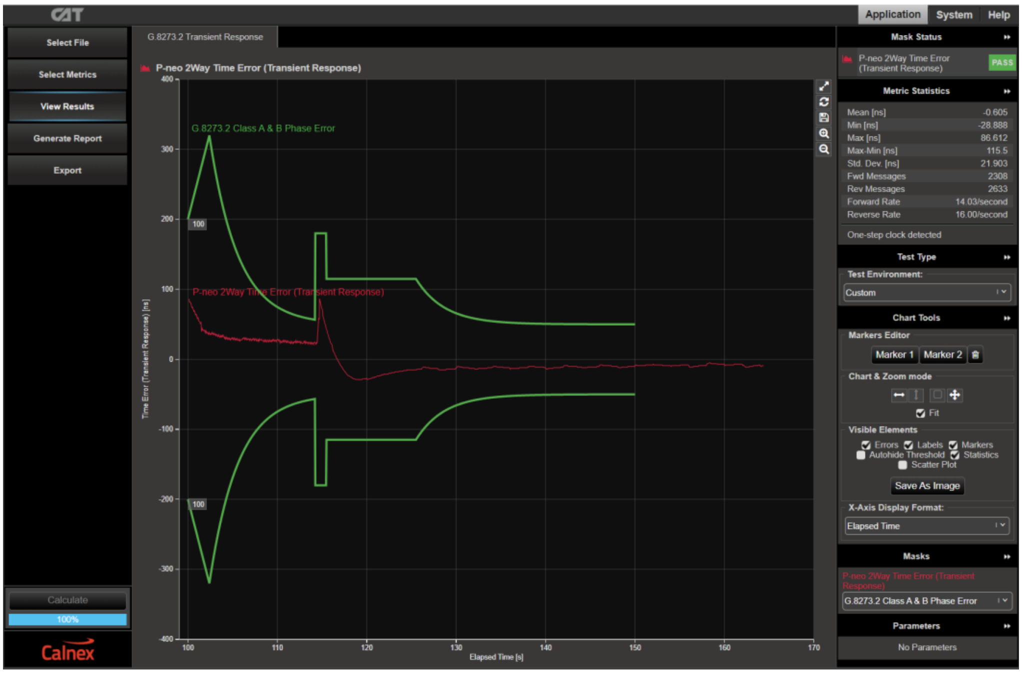
1. In **CAT**, click on **Select Metrics** and enable the **G.8273.2 Transient Response** metric followed by the **Calculate** button.

   All other metrics can be unchecked if required to limit conformance checking to the relevant metric only.



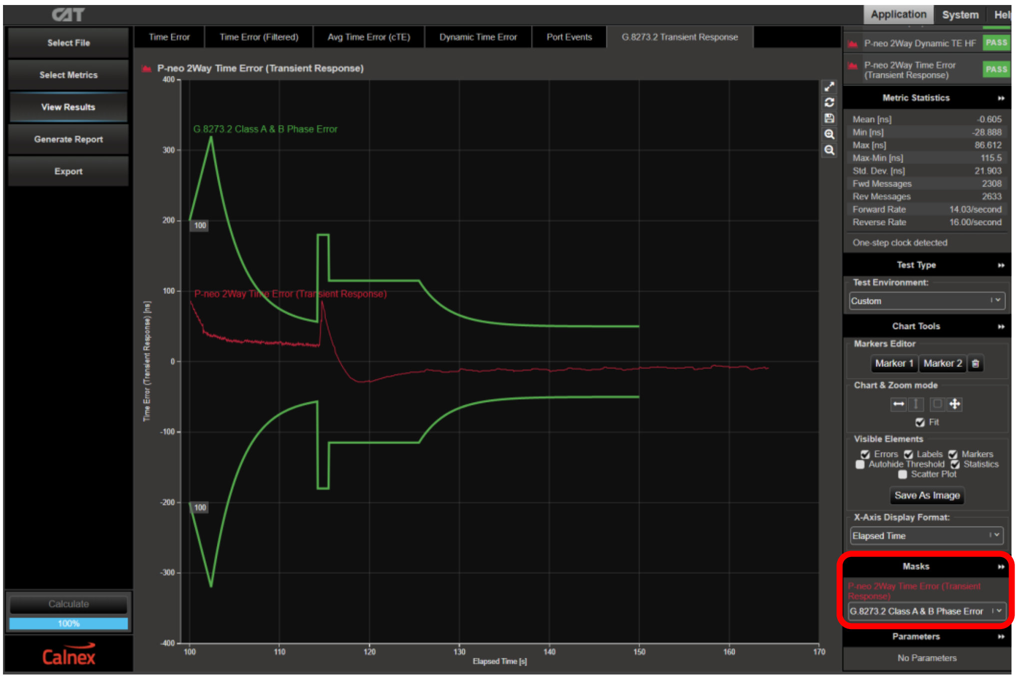
NOTE: Due to the application of the transient event, the other Time Error results will be impacted and thus cannot be relied upon to provide representative results – other aspects of Time Error performance should be analyzed in separate test runs.

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:

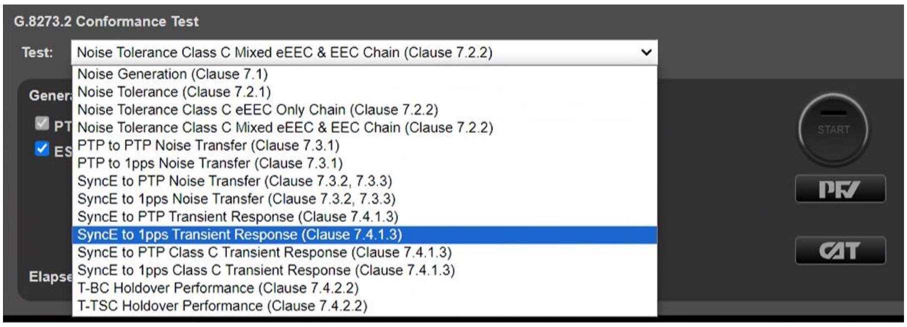
DUT Class	Dynamic MTIE LF Mask
Class A & B	G.8273.2 Class A & B Phase Error
Class C	G.8273.2 Class C Phase Error



4. The T-BC 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.

9.2 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.

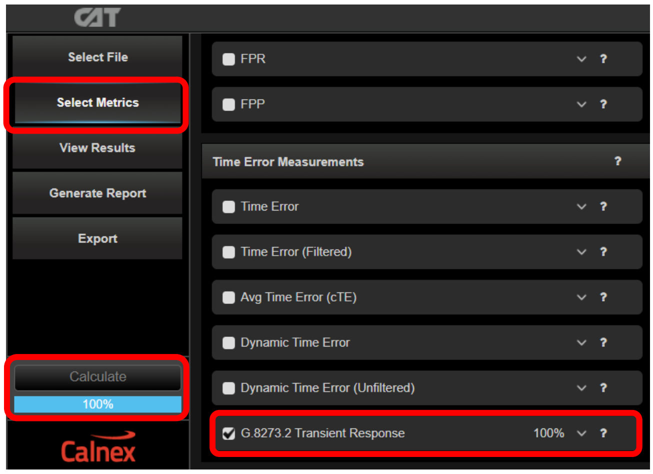
3. Once the DUT is stable, in the **Stimulus/Measurement** section, press **Start** to run the prescribed SyncE wander and ESMC state change stimulus and simultaneous 1PPS measurement.

   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

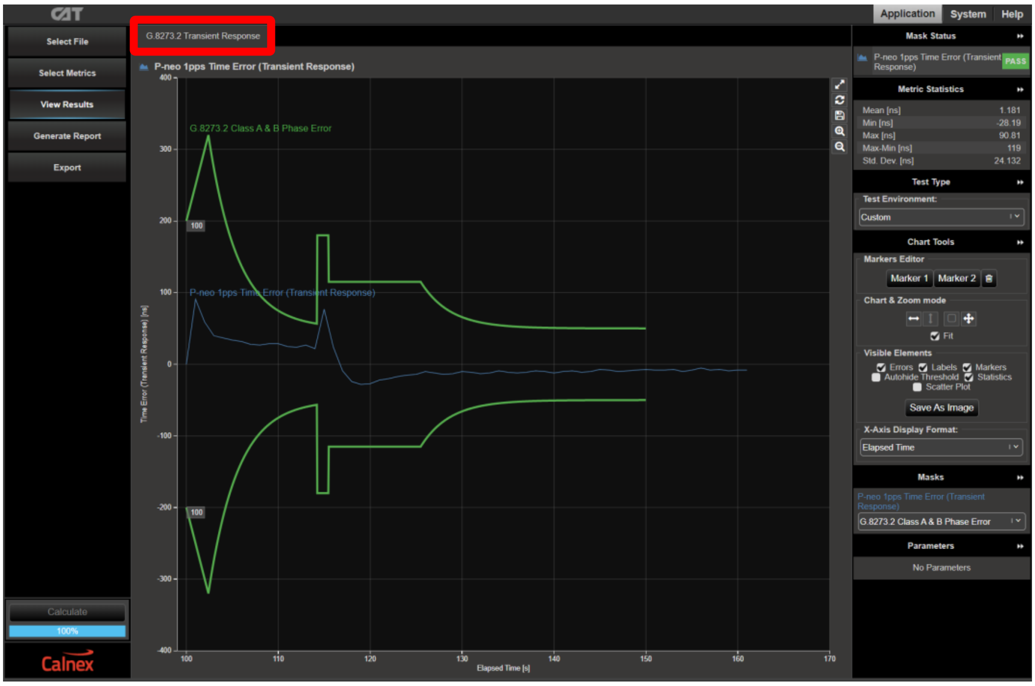
1. In the CAT, click on **Select Metrics** and enable the **G.8273.2 Transient Response** metric followed by the **Calculate** button.

   All other metrics can be unchecked if required to limit conformance checking to the relevant metric only.



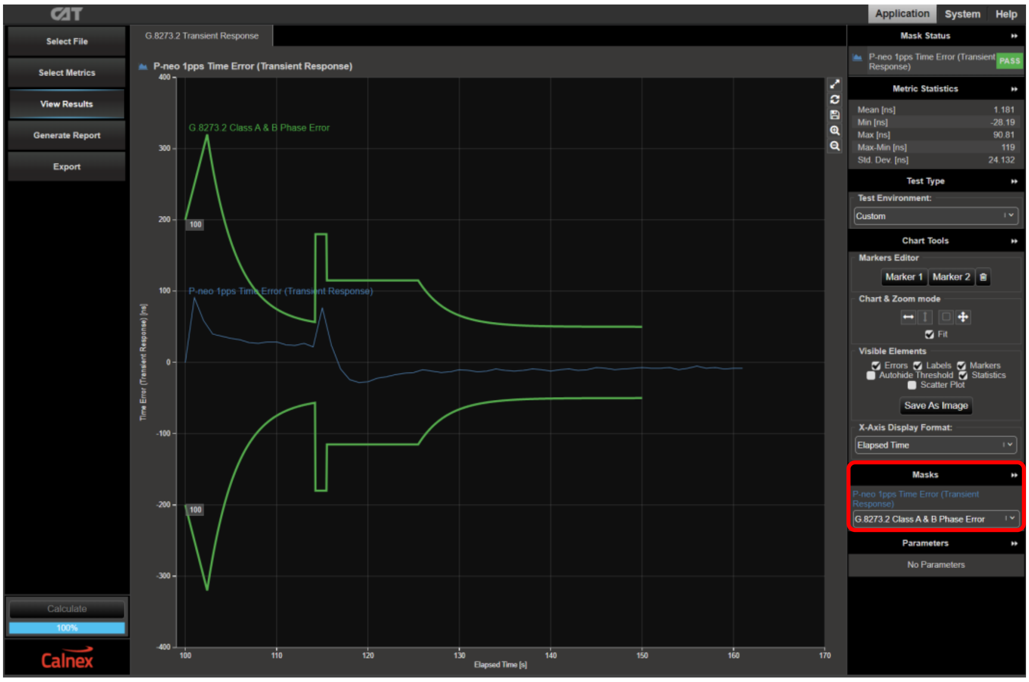
NOTE: Due to the application of the transient event, the other Time Error results will be impacted and thus cannot be relied upon to provide representative results – other aspects of Time Error performance should be analyzed in separate test runs.

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.

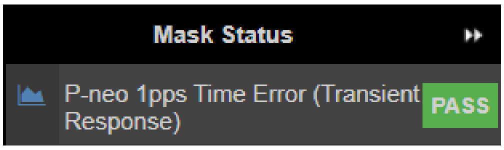


3. Select the mask that is applicable to the class of conformance test run:

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-BC 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.



10 Holdover Performance (Clause 7.4.2)

Test Description

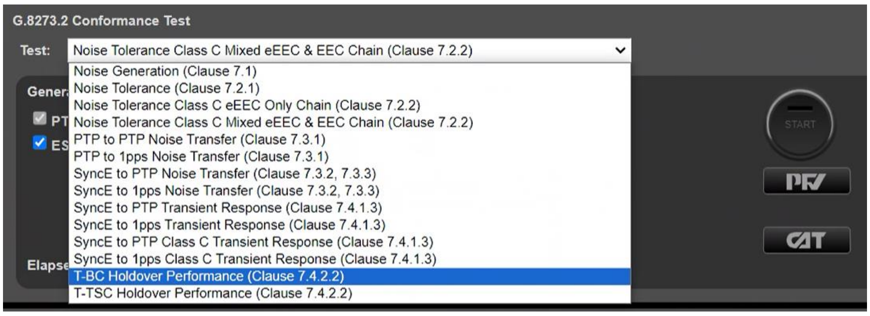
Holdover performance is checked by measuring the phase/time output in the event of the loss of the PTP input to the T-BC.

Currently, only Classes A and B have defined limits for holdover performance, however, there are different limits for constant and variable temperature conditions. The limits apply to both PTP and 1PPS outputs of the device; 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

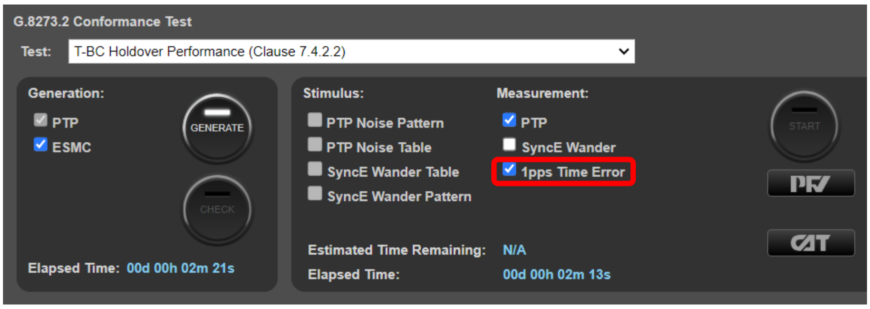
Measurement Process

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-BC Holdover performance (Clause 7.4.2.2).**



5. If a 1PPS output is to be concurrently measured from the DUT, from the **Measurement** section of the **Conformance Test** app, check the **1pps Time Error** checkbox.

   Note: Verification by the 1PPS only is NOT recommended for Boundary Clock devices since it is the PTP flow that the downstream device will use.



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 a **2WayTE measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.

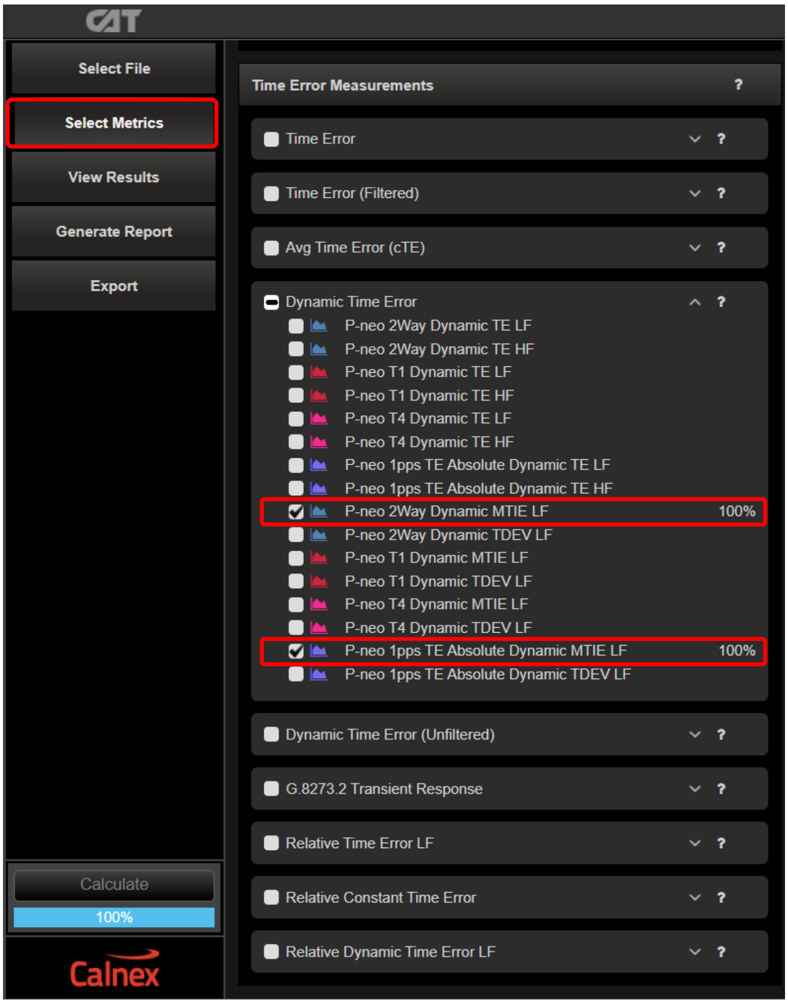
7. Once the DUT is stable, in the **Stimulus/Measurement** section, press **Start** to simulate loss of PTP input signal to the DUT and make simultaneous PTP performance measurements.

   The minimum duration for a constant temperature test is 1000 seconds, for a variable temperature test it is 10,000 seconds.

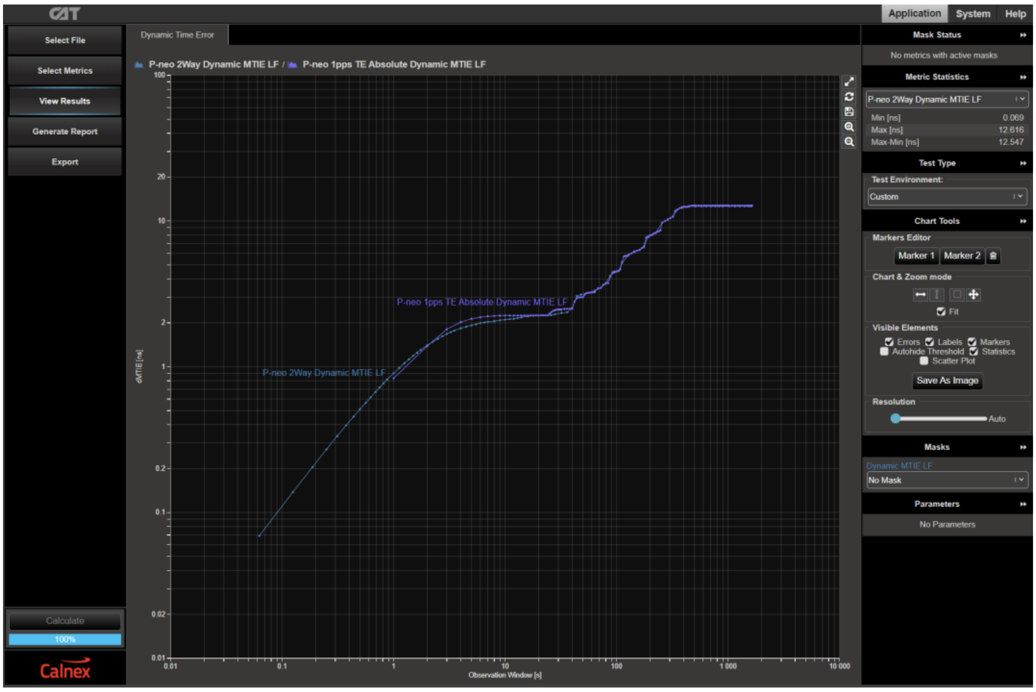
8. In the **Stimulus/Measurement** section, press **Stop** to stop the test.

Results Analysis

1. In the CAT, click on **Select Metrics** and ensure the **Dynamic MTIE LF** is enabled for all signal types measured. Disable all other metrics, then press the **Calculate** button.

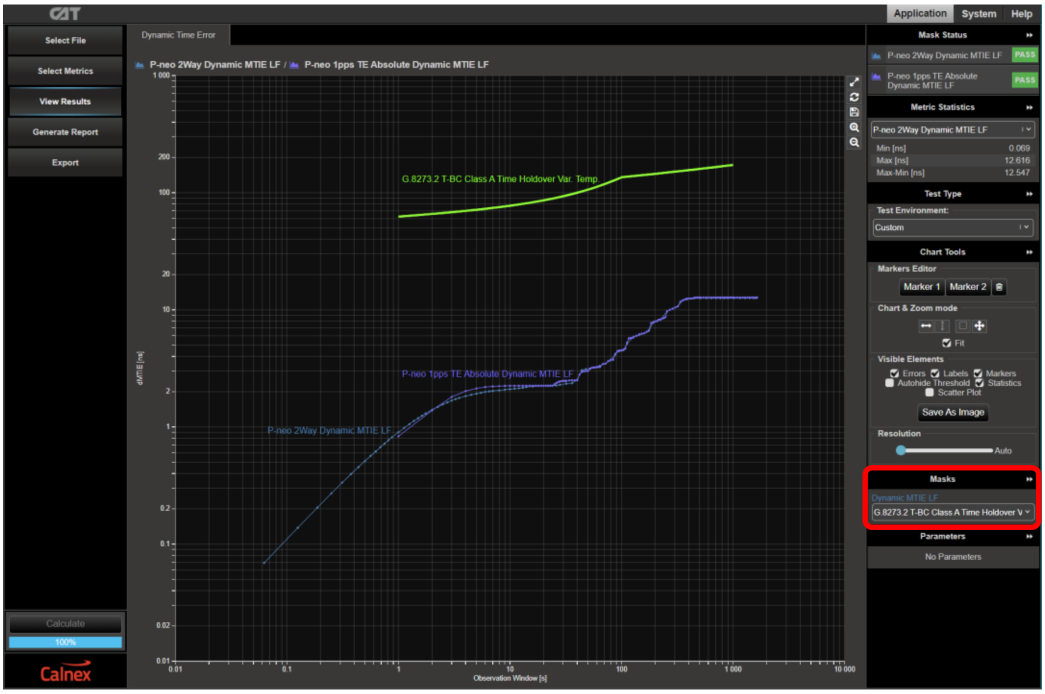


2. Select **View Results** and the **Dynamic Time Error** tab will be displayed.

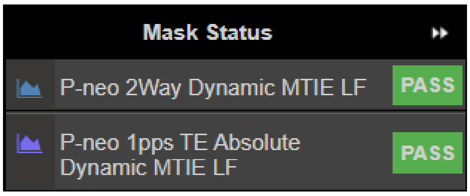


3. Select the appropriate mask for the device class and the temperature conditions of the test:

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-BC 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-BC

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.

<table>
<tr><th>Test</th><th>Objective</th><th>Test Method</th><th colspan="5">Output Limit (PTP and 1PPS) [1]</th></tr>
<tr><td rowspan="6">Time Error Generation
(G.8273.2, Section 7.1)</td><td rowspan="6">With stable input references, measure the inherent time error (Max|TE_L|, Max|TE|, cTE and dTE) produced by the internal clock.</td><td rowspan="6">Apply a stable time reference to the PTP input.
Apply a stable frequency reference to the SyncE input.
Repeat without a SyncE reference[2].</td><td></td><td>Class A</td><td>Class B</td><td>Class C</td><td>Class D</td></tr>
<tr><td>Max|TE_L|:[3]</td><td>-</td><td>-</td><td>-</td><td>≤ 5ns</td></tr>
<tr><td>Max|TE|:[4]</td><td>≤ 100ns</td><td>≤ 70ns</td><td>≤ 30ns</td><td>≤ 15ns
(Proposed)</td></tr>
<tr><td>cTE:</td><td>≤ 50ns</td><td>≤ 20ns</td><td>≤ 10ns</td><td>≤ 4ns
(Proposed)</td></tr>
<tr><td>dTE_{LF}:[5]</td><td colspan="2">40ns MTIE,
4ns TDEV</td><td>10ns MTIE
2ns TDEV</td><td>3ns MTIE
1ns TDEV
(Proposed)</td></tr>
<tr><td>dTE_{HF}:[6]</td><td colspan="2">70ns p-p</td><td>30ns p-p</td><td>15ns p-p
(Proposed)</td></tr>
<tr><td rowspan="3">Relative Time Error Noise Generation
(G.8273.2, Section 7.1.4)</td><td rowspan="3">With stable input references, measure the difference in time error between two phase and time outputs.</td><td rowspan="3">Apply a stable time reference to the PTP input.
Apply a stable frequency reference to the SyncE input.</td><td></td><td>Class A</td><td>Class B</td><td>Class C</td><td>Class D</td></tr>
<tr><td>cTE_R</td><td>FFS</td><td>FFS</td><td>≤ 12ns</td><td>FFS</td></tr>
<tr><td>dTE_{RL} MTIE</td><td>FFS</td><td>FFS</td><td>≤ 14ns</td><td>FFS</td></tr>
<tr><td>Time Error Tolerance
(G.8273.2, Section 7.2)</td><td>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</td><td>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].</td><td colspan="5">No output performance limit.
Clock under test should not:
• generate alarms
• switch reference
• go into holdover</td></tr>
</table>

[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-PTP/1PPS transfer function**: • Low-pass filter (undefined order or shape) • Bandwidth from 0.05 to 0.1Hz **SyncE-to-PTP/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 PTP/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 PTP/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-BC 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-BC 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

[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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