

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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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-100G	100GbE interface support (if the DUT has 100G interfaces)
Opt. NEO-40G	40GbE interface support (if the DUT has 40G interfaces)
Opt. NEO-PTP-G.8275.1	Emulation of G.8275.1 PTP Master and Subordinate 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)

Software version: 04.00.XX and later. For Background Traffic: 09.00.XX and later.

Accessories

- Optical transceivers as required
- Cables as required

Document References

- 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
- IEEE Std 1588TM - 2008 IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
- Calnex Technical Note: Cabling Considerations (CX5009)

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 the user to design their 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 or Paragon-neo A (PAM4) to the Device-Under-Test

Paragon-neo Front Panel

Optical Interfaces:

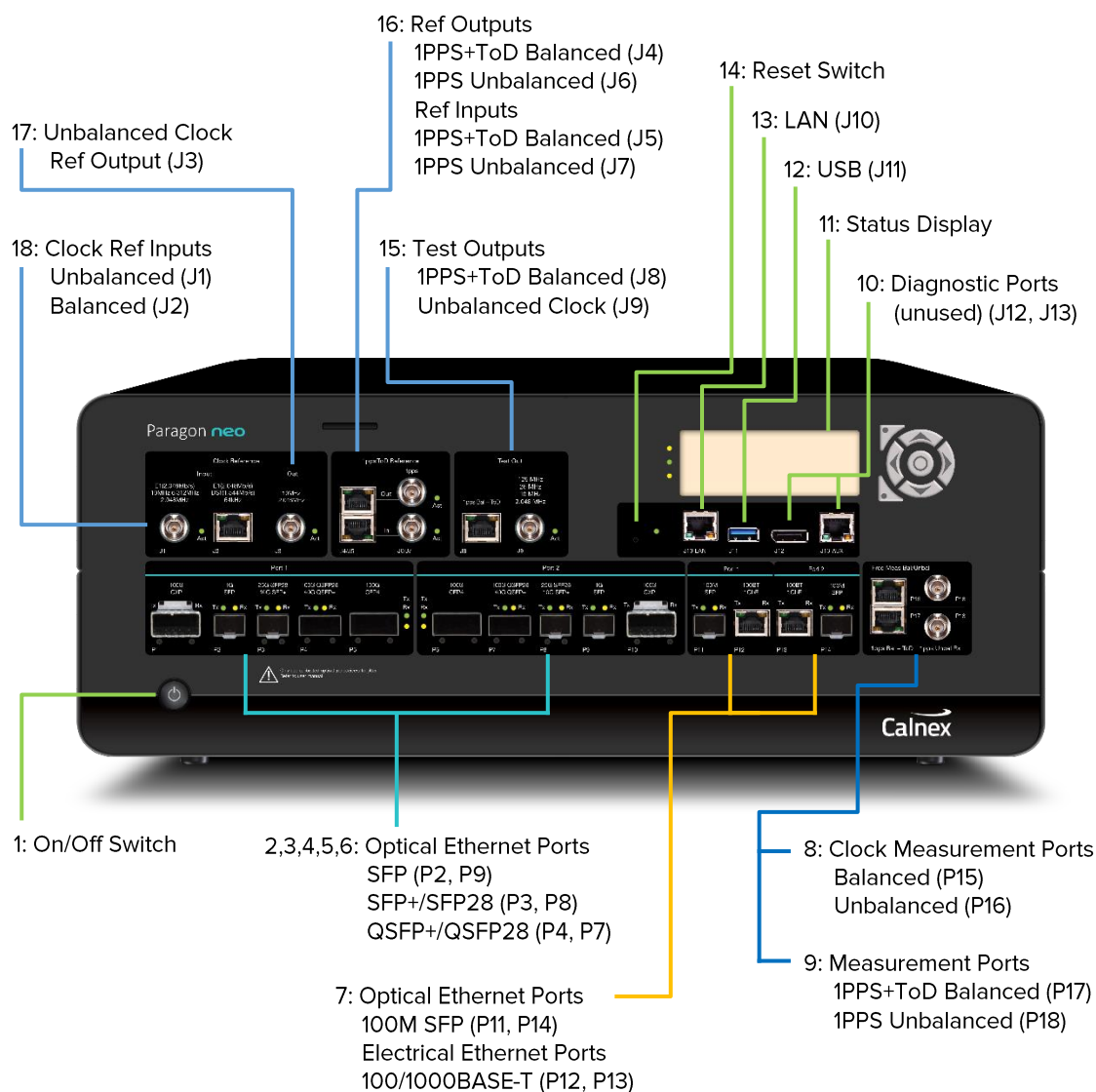
- 100GbE (QSFP28)
- 50GbE (QSFP28)
- 40GbE (QSFP+)
- 25GbE (SFP28)
- 10GbE (SFP+)
- 1GbE (SFP)

Reference Clock Inputs:

- 2.048/10MHz (Recommended)

1PPS Measurement Inputs:

- 1PPS Balanced (RJ48)
- 1PPS Unbalanced (BNC)



Paragon-neo A (PAM4) Front Panel

PAM4 Optical Interfaces:

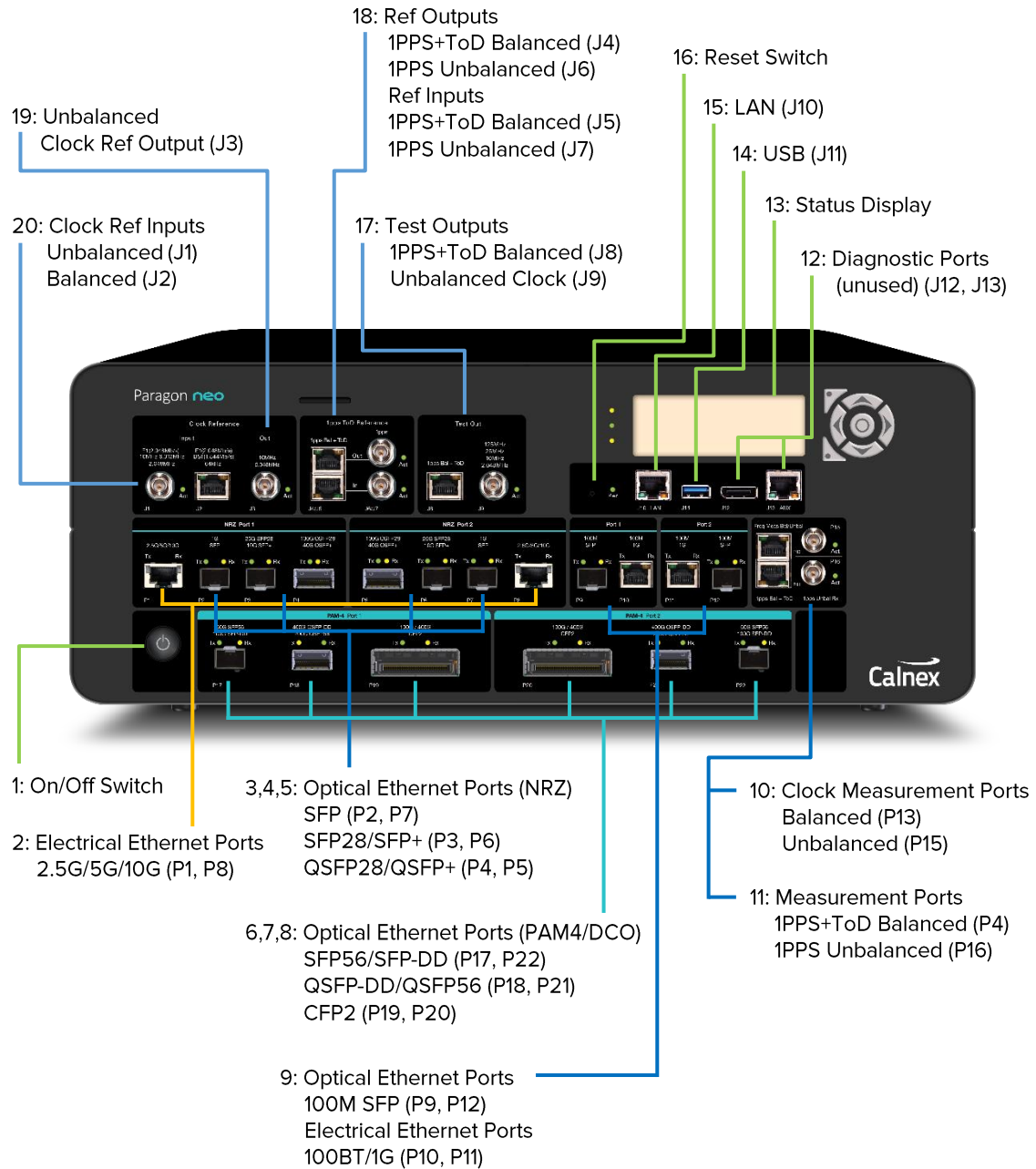
- 400GbE (QSFP-DD)
- 50GbE (SFP56)

Reference Clock Inputs:

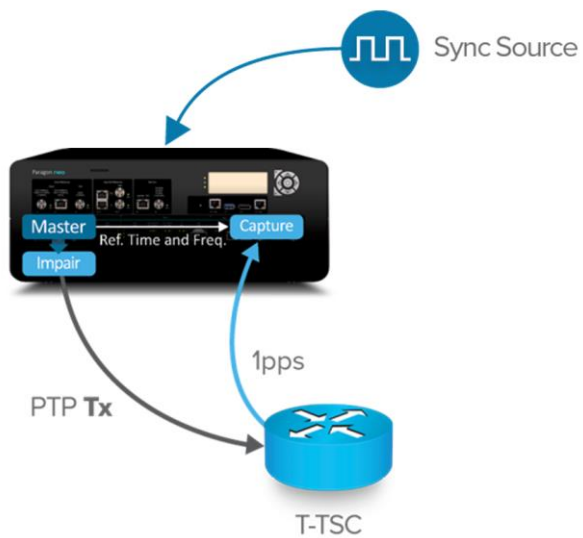
- 2.048/10MHz (Recommended)

1PPS Measurement Inputs:

- 1PPS Balanced (RJ48)
- 1PPS Unbalanced (BNC)



Connections to Device Under Test



1. Connect Port 1 (Master side of Paragon-neo) to the T-TSC Subordinate interface.
2. Connect the 1pps or 1pps+ToD output from the T-TSC to the Paragon-neo 1pps Measurement Input
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:

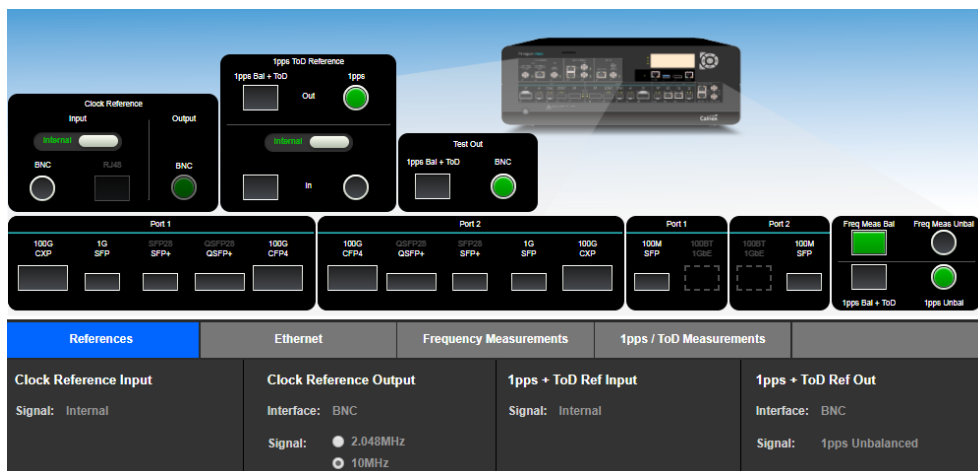
- 4.1. Connection to Paragon-neo
- 4.2. Configuration of Physical Connections
- 4.3. Test Configuration
- 4.4. Device Connection Settings
- 4.5. Background Traffic

4.1. Connection to Paragon-neo

1. Verify the physical connections have been completed as described in Section 3.
2. From a PC on the same network, open a browser and enter the IP address of the Paragon-neo unit.
3. If directed to the Home Page, select **PTP** operating mode.
4. See the Paragon-neo Getting Started Guide for more details.

4.2 Configuration of Physical Connections

1. Select **Setup Ports** then from the onscreen display, 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 1 decimal place to ensure the best accuracy of test and measurement.



4.3. Test Configuration

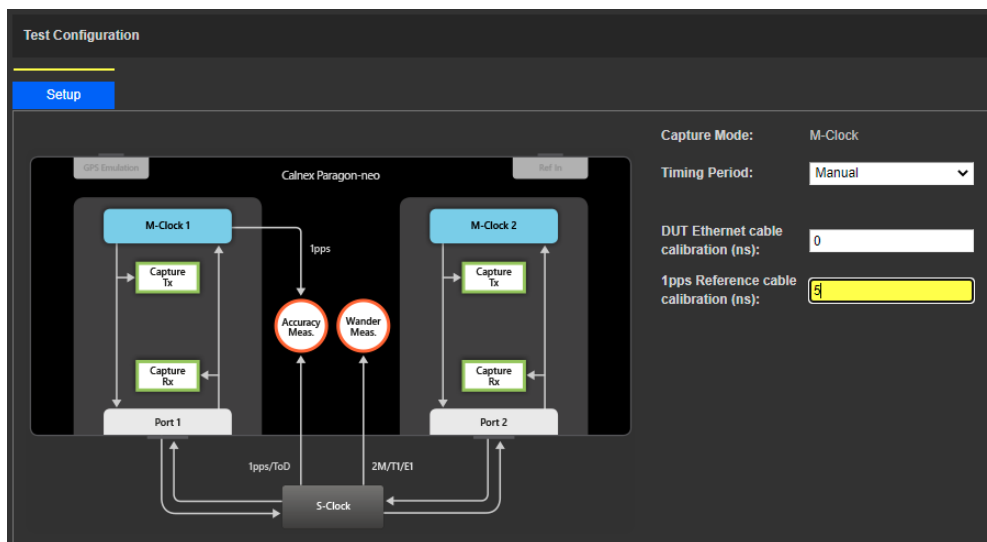
1. Select **Run Apps**, then the **Conformance Test** preset.



4.4. Device Connection Settings

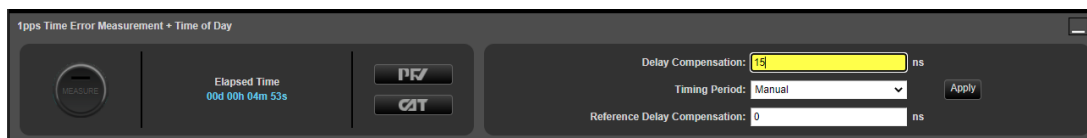
It is assumed that the G.8275.1 profile will be used in testing as per the G.8273.2 requirements, and as a result, testing will be carried out using L2 encapsulation in Multicast mode. The Paragon-neo Master emulation can be configured to use other options, e.g. unicast, UDP/IPV4 etc., however, it should be noted that these do not conform to the G.8273.2 recommendation requirements.

1. In the **PTP Emulation** app, choose **Test Config** and enter the 1pps Reference Delay cable calibration value if required. Delay values are entered in ns and should be entered to one decimal place for the most accurate results. For coaxial cable, values of 4.5 to 5ns per meter of cable are typical; it is recommended to independently verify the cable delay. Once the required values have been set, click **Apply**.



2. In the **1pps Time Error Measurement** 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 User Interface.



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.

The screenshot shows the 'Background Traffic Generation (Port1)' application window with the 'General' tab selected. The 'Encapsulation' dropdown is set to 'IPv4'. The 'Source MAC Address' is 'a0:00:00:00:00:aa', 'Destination MAC Address' is 'a0:00:00:00:00:bb', 'Source IP Address' is '192.168.0.1', and 'Destination IP Address' is '192.168.0.2'. A 'GENERATE' button is on the left, and 'Apply' and 'Undo' buttons are at the top right.

2. Select the **VLAN Tags** tab and if required, configure the VLAN parameters.

The screenshot shows the 'Background Traffic Generation (Port1)' application window with the 'VLAN Tags' tab selected. The 'Tagging Mode' dropdown is set to 'IEEE 802.1ad "QinQ"'. The 'Frame header excerpt' shows a table with columns: Source MAC, 802.1Q Tag(2), 802.1Q Tag(1), and EtherType. The table contains values for TPID (hex), PCP, DEI, and VID for both tags.

Source MAC	802.1Q Tag(2)	802.1Q Tag(1)	EtherType
TPID (hex): 88a8	TPID (hex): 8100		
PCP: 4	PCP: 4		
DEI: 0	DEI: 0		
VID: 512	VID: 256		

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

The screenshot shows the 'Background Traffic Generation (Port1)' application window with the 'Pattern' tab selected. The 'Pattern' dropdown is set to 'Network Traffic model 2', 'Loading (%)' is '80', and 'Packet Payload' is 'Pseudo Random Binary Sequence'. Below are two tables for 'Pattern' and 'Burst' configurations.

Pattern	
Duration (s):	10
Packet Size (bytes)	Distribution (%)
1518	60
64	30
576	10

Burst	
Duration (s):	2
Packet Size (bytes)	
1518	

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



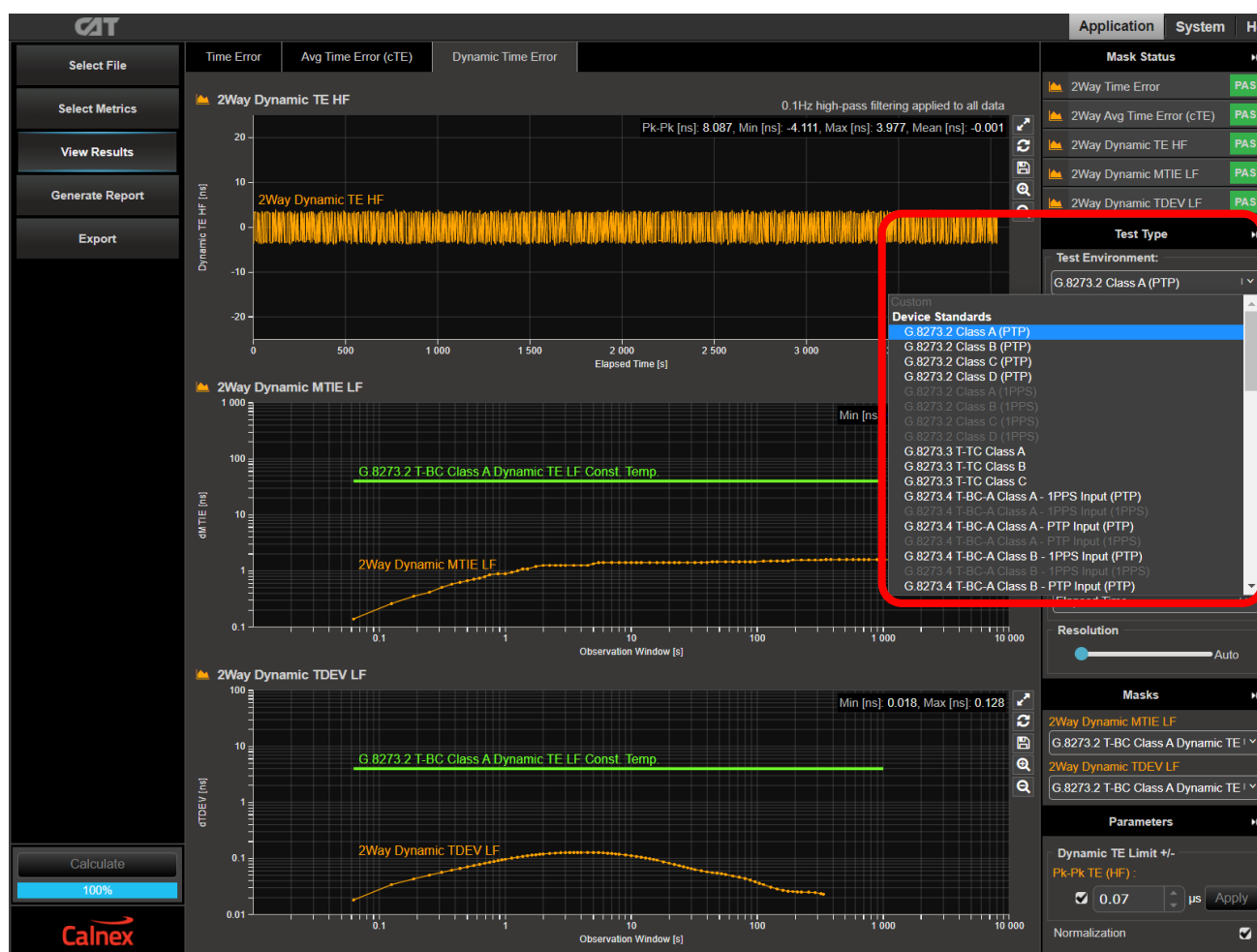
5. Analysing Results using CAT

The tests in this document detail the steps to manually set the metrics, masks and thresholds to those required to test for G.8273.2 conformance, however, it is also possible to use the **Test Environment** function to automatically apply the relevant settings.

The Test Environment function automatically configures the displayed metrics, masks, and thresholds to a range of preset values such as those required for testing compliance to device or network standards.

The environments that are available for selection change dynamically based on the type of measurement data that is in the loaded capture file(s), e.g. if PTP measurement data is present then Test Environments that contain PTP metrics will be available.

In the example below G.8273.2 T-BC Class A device with PTP measurements has been selected, the relevant metrics Time Error, Avg Time Error (cTE) and Dynamic Time Error only are displayed, and the masks and thresholds have been set to those relevant to that device type and class.



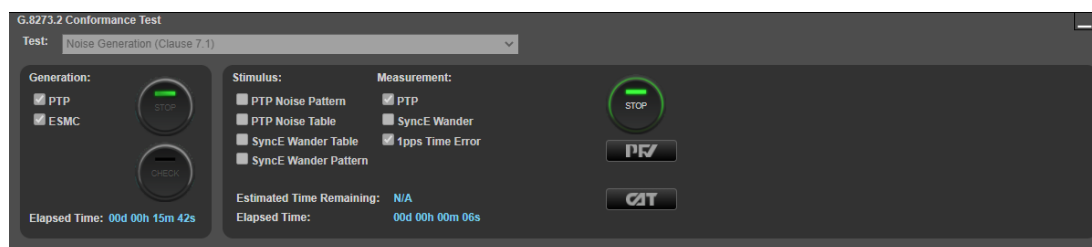
6. Noise Generation – G.8273.2 Clause 7.1

Test Description

The noise generation of a T-TSC represents the amount of noise produced at its output when there is an ideal input reference packet timing signal. The noise generation has two components: constant time error (cTE) and dynamic time noise generation (Max|TE_L| or Max|TE_L|, dTE).

Measurement Process

1. Confirm that preconfigured settings within the PTP Emulation app are appropriate for the current test scenario, as described in Section 4.4.
2. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.
3. From the **Test:** drop-down menu, select **Noise Generation (Clause 7.1)**. In the **Stimulus/Mechanism** section, under **Measurement** ensure that **1pps Time Error** is selected
4. In the **Generation** section of the conformance test app, press **Generate**. This starts PTP and ESMC message generation, allowing the DUT to lock and stabilize. Pressing **Check** will run a simultaneous data capture and will open the **CAT** in a new tab to check the current timing performance. In this case, you should wait for a **1pps TE measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.
5. Once the DUT is stable, press **Stop** on the Check button, then **Start** to run the Noise Generation measurement, which should be run for at least 2000s.



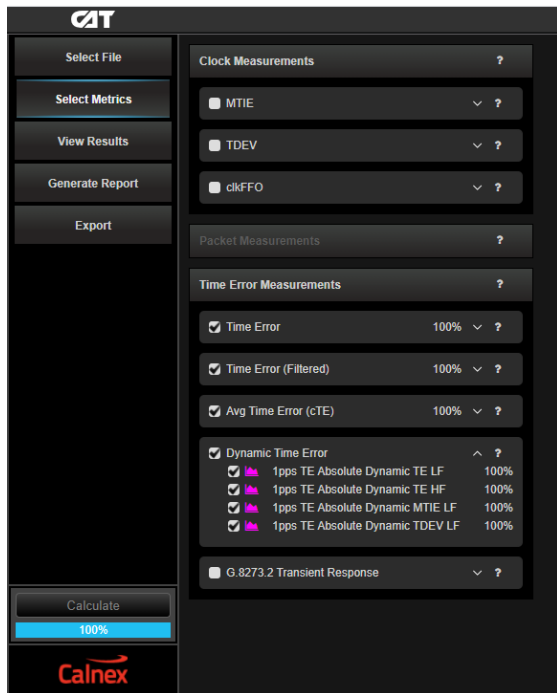
Measurements: Time Error results can either be viewed during capture or after capture has been stopped.

5. Click the **CAT** button to open the Calnex Analysis Tool in a new browser tab and display **Time Error** metrics.



For a 1pps capture, the metrics of interest are **Time Error**, **Time Error – Filtered (TE_L)**, **Avg. Time Error (cTE)** and **Dynamic Time Error**.

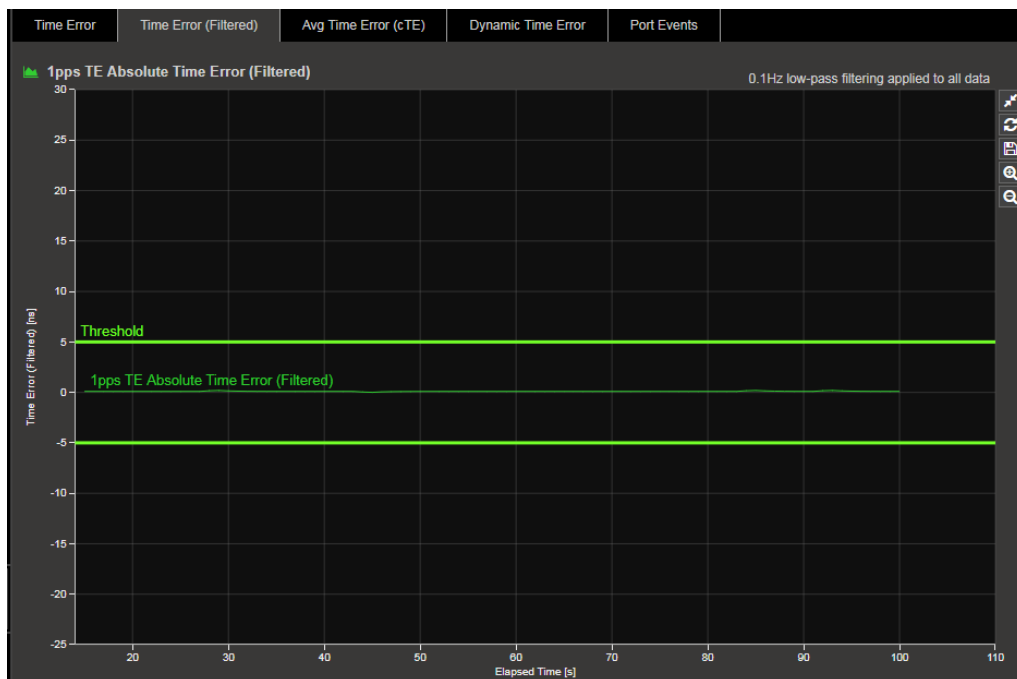
Note: The complete set of metrics can be viewed by expanding the appropriate list in the Measurement Analysis block by clicking on the down arrow against each metric. Tick those of interest then press **Calculate** to view.



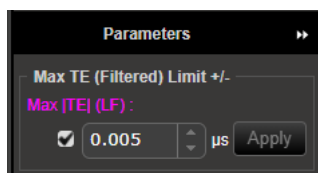
Individual graphs can be displayed by double-clicking on the desired graph. To return to the multi-graph display, double-click on the single-graph display.

Time Error Results ($\text{Max}|TE_L|$) – For Class D device testing

1. Select the **Time Error (Filtered)** tab to display the **0.1Hz low-pass filtered** Time Error results:



2. Check your result conforms to the Class D G.8273.2 requirement: **$\text{Max}|TE_L|$ of 5ns**. This is set as the threshold in the *Max TE (Filtered)* limit as 0.005 μs :



Time Error Results (Max|TE|) - For Class A, B and C device testing

1. Select the **Time Error** tab to display the **unfiltered** Time Error results.



2. Check your result conforms to the relevant G.8273.2 spec [Clause 7.1]:

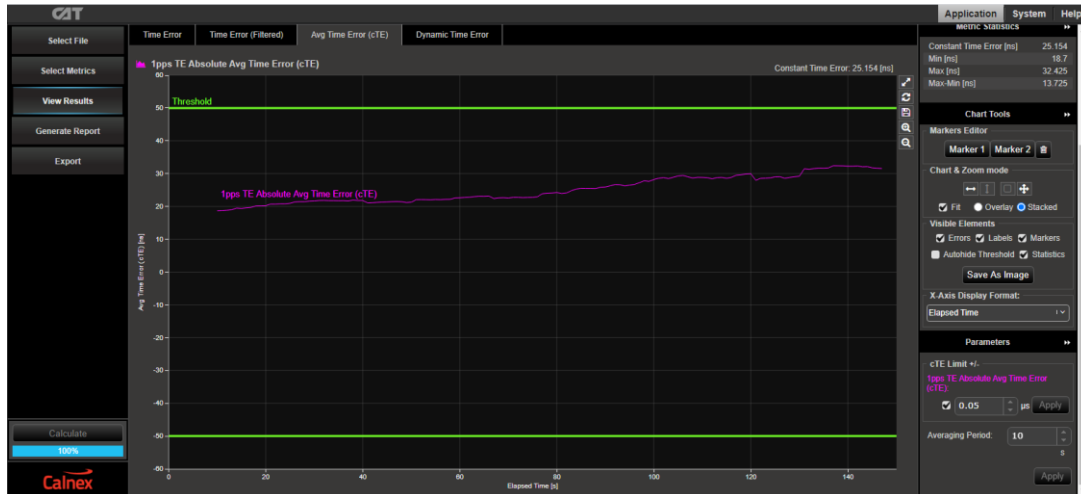
T-TSC Class	Max TE (ns)
A	100
B	70
C	30
D	FFS

For other applications, adjust the applied limits based on the class of device which is being tested.

Time Error Results (Constant Time Error)

1. Select the Avg Time Error (cTE) metric tab to display the cTE graph.

Clause 7.1.1 of G.8273.2 states “an estimate of constant time error should be obtained by averaging the time error sequence over 1 000 s.” To align with this definition, the Constant Time Error displayed is a result of a moving average of 1000s being applied to the raw Time Error results. This removes packet-to-packet noise that will be filtered out by the terminating clock within the T-TSC.

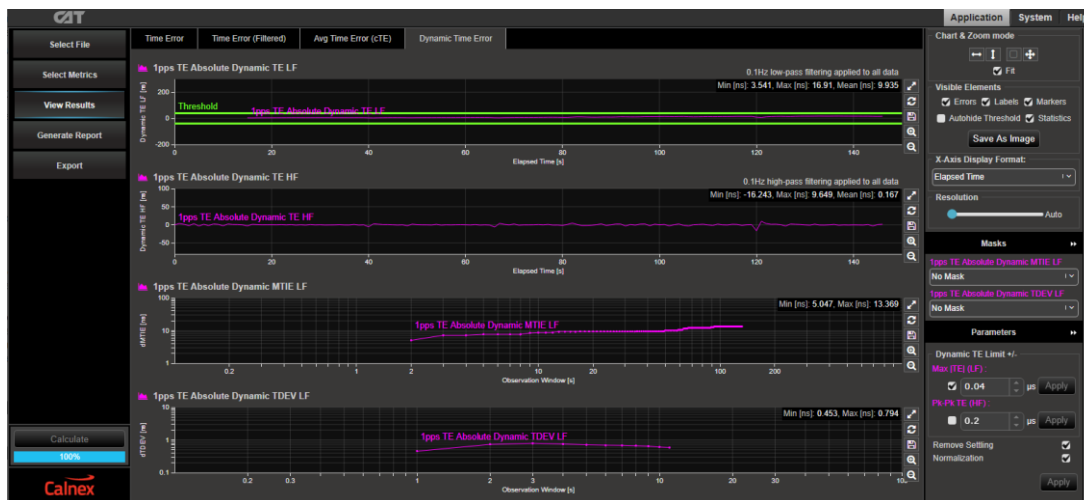


2. Adjust the applied cTE limit in the **Parameters** section based on the class of device that is being tested to confirm your result conforms to the relevant G.8273.2 spec [Clause 7.1.1]:

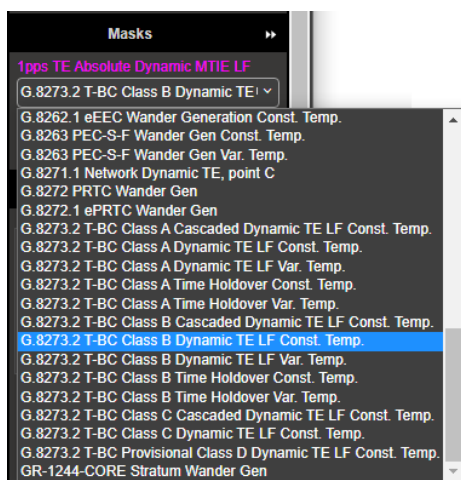
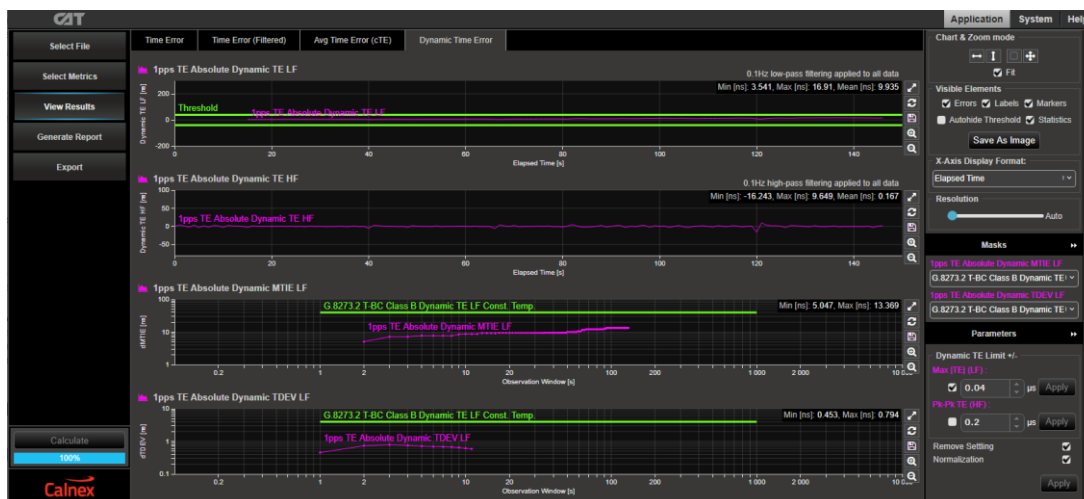
T-TSC Class	Permissible cTE range (ns)
A	±50
B	±20
C	±10
D	FFS

Time Error Results (Dynamic Time Error)

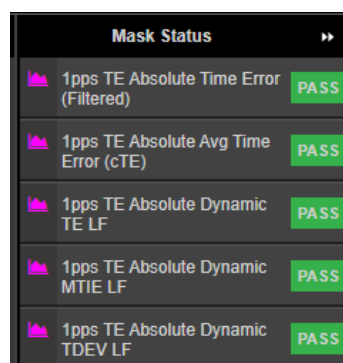
1. Select the **Dynamic Time Error** tab to display the **filtered** Time Error results. This will display the Low Frequency and High Frequency Dynamic Time Error components (dTE_L and dTE_H, respectively) as measurements. These results are filtered at 0.1Hz.



2. Compare the results against the ITU-T limits by loading the masks appropriate to the DUT Class for the MTIE and TDEV metrics.



3. Check for PASS/FAIL against the applied masks by observing **PASS** or **FAIL** in the Mask Status panel:



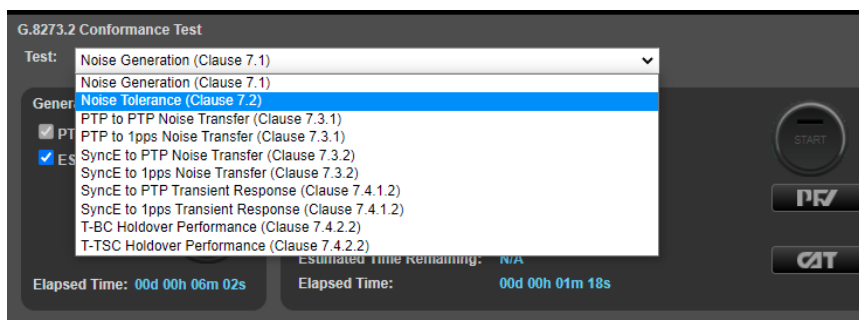
7. Time Noise Tolerance – G.8273.2 Clause 7.2

Test Description

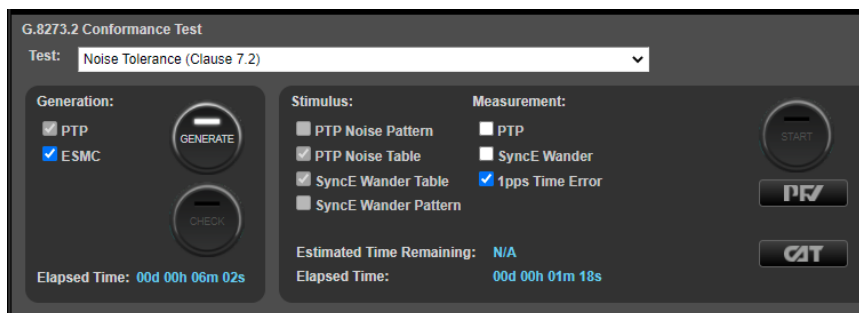
This test checks whether the clock can maintain network limits at the output with maximum noise at the input.

Measurement Process

1. Confirm that preconfigured settings within the PTP emulation app are appropriate for the current test scenario, as described in Section 4.4.
2. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.
3. From the **Test:** drop-down menu, select **Noise Tolerance (Clause 7.2)**.
4. In the **Stimulus/Measurement** section, under **Measurement** ensure that **1pps Time Error** is selected



5. In 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 and will open the **CAT** in a new tab to check the current timing performance. In this case, you should wait for a **1pps TE measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.
6. Once the DUT is stable, press **Stop** on the Check button, then **Start** to run the Noise Tolerance test. PTP and SyncE Stimulus as per the relevant clause of G.8273.2 will be applied, and capture will be started.



6. Once the test stimuli have finished and at least 1000s have passed, select **Stop Capture** to end the measurement.

Expected Outcome

To pass, the DUT must maintain reference and not attempt to switch reference or enter holdover state. This must be determined on 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.

8. Time Noise Transfer – G.8273.2 Clauses 7.3.1 and 7.3.2

Test Description

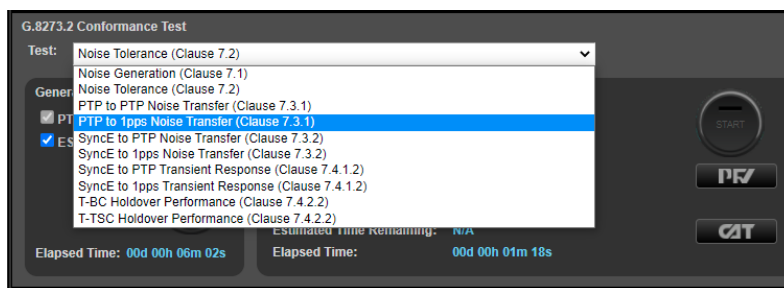
This test measures how Time Error on the input is transferred to the output.

Measurement Process

1. Confirm that preconfigured settings within the PTP Emulation app are appropriate for the current test scenario, as described in Section 4.4.
2. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.

8.1. PTP to 1pps Transfer

1. From the **Test:** drop-down menu, select **PTP to 1pps Noise Transfer (Clause 7.3.1)**.
2. In the **Stimulus/Measurement** section, under **Measurement** ensure that **1pps Time Error** is selected
3. From the **Generation** section of the conformance test app, press **Generate**. This starts PTP and ESMC message generation, allowing the device under test to stabilize. Pressing **Check** will open **CAT** in a new tab, to allow you to check the 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

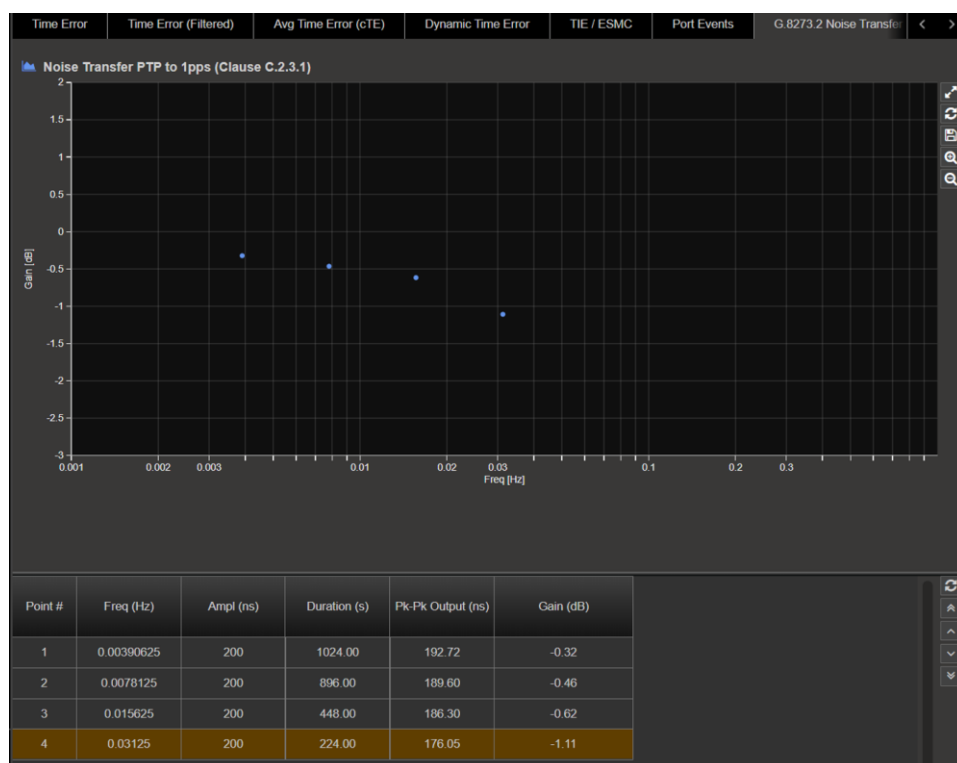


4. Once the DUT is stable, press **Stop** on the Check button then in the **Stimulus/Measurement** section press **Start** to start the 1pps measurement and application of the prescribed PTP Noise Stimulus.

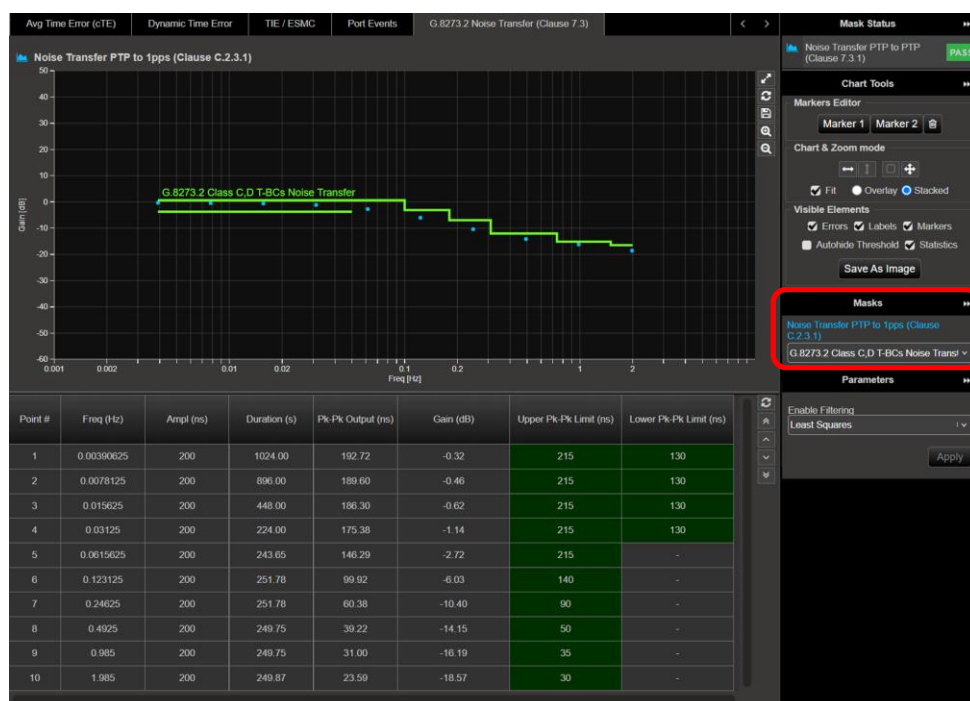
PTP Noise (Time Error) is applied as per G.8273.2 Amendment 1 (Appendix VI).

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**.

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.



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

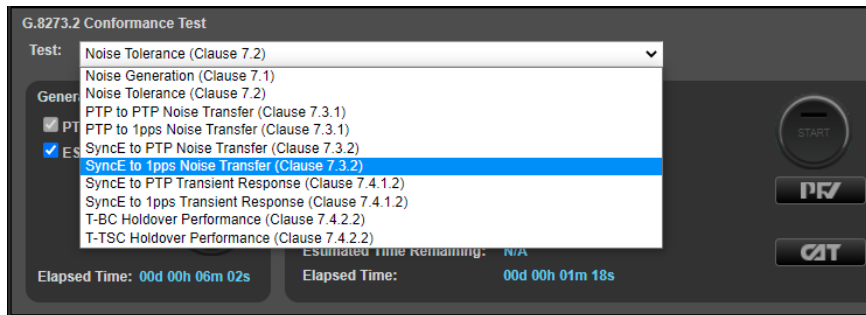


Note that the Pk-Pk limits as defined in G.8273.2 are defined as a value $\pm N$ to account for added noise generation of the DUT. The value of $N = 10\text{ns}$ has been selected for the pass/fail limits as this provides the balance between the ability to measure accurately and give confidence that 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>

8.2. SyncE to 1pps Transfer

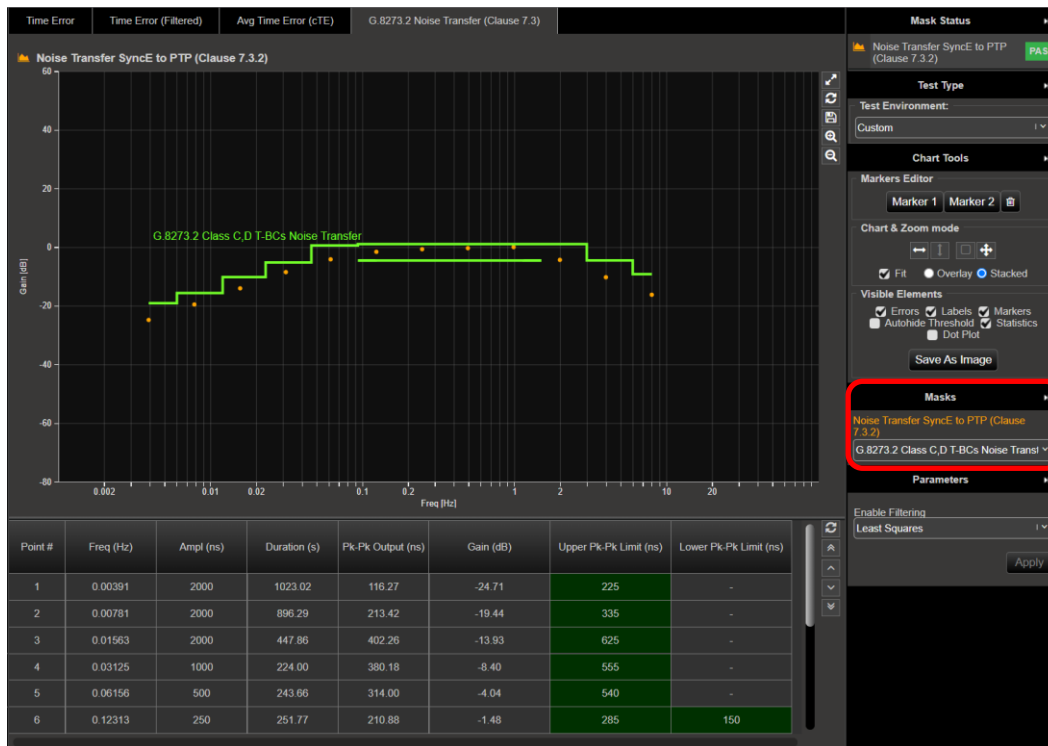
1. From the **Test:** drop-down menu, select **SyncE to 1pps Noise Transfer (Clause 7.3.2)**.
2. In the **Stimulus/Measurement** section, under **Measurement** ensure that **1pps Time Error** is selected.
3. From the **Generation** section of the conformance test app, press **Generate**. This starts PTP and ESMC message generation, allowing the device under test to stabilize. Pressing **Check** will open the **CAT** in a new tab to allow you to check the 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.



4. Once the DUT is stable, press **Stop** on the Check button then in the **Stimulus/Measurement** section, press **Start** to start the 1pps measurement and application of the prescribed PTP Noise Stimulus.
5. 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.



- By selecting the mask applicable to the DUT class in **Masks** from the right-hand side of the CAT tool, 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 $\pm N$ to account for added noise generation of the DUT. The value of $N = 25\text{ns}$ 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>

9. Packet Layer Transient Response and Holdover Performance – G.8273.2

Section 7.4.1.2

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 at 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, a T-TSC must either stop using the SyncE signal or turn off the low-pass filter to allow 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 Amd. 2 defines the following mask for the clock output in the event of a transient on the SyncE input:

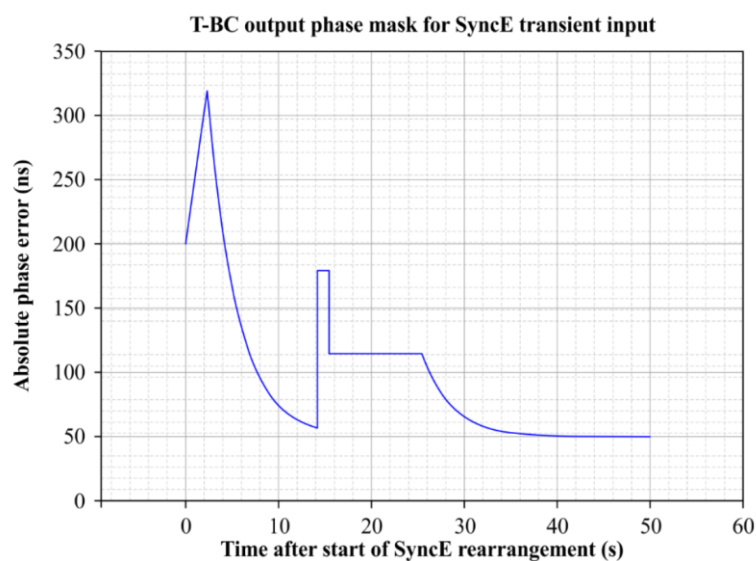


Figure B.1 from G.8273.2 Annex B – Phase error mask during a SyncE transient

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).

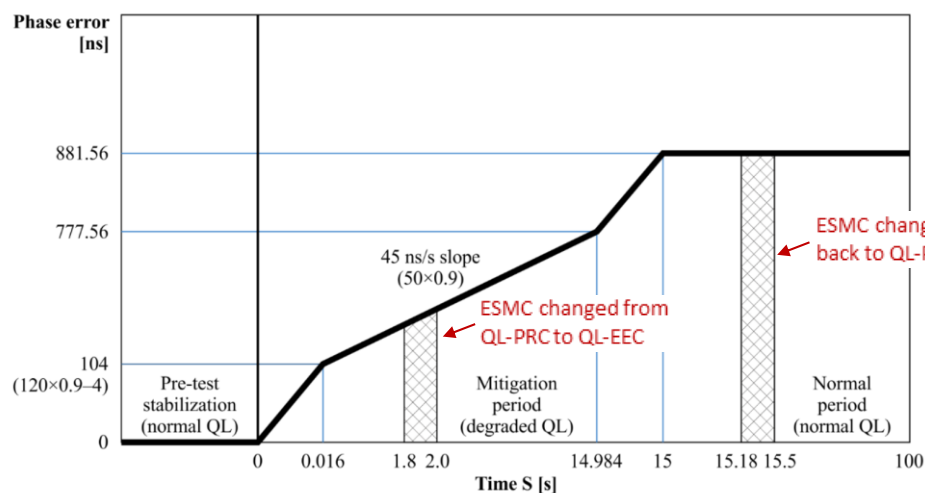


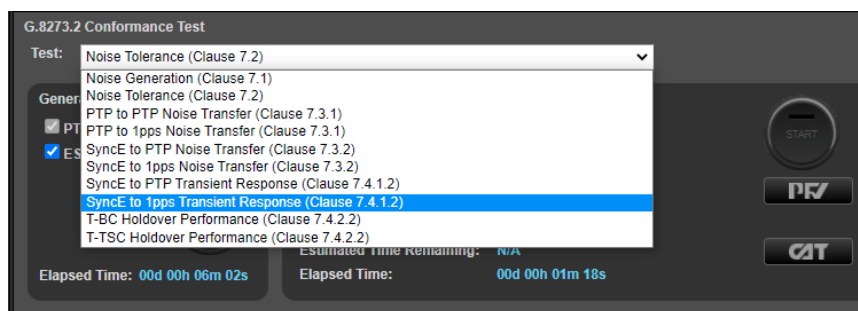
Fig. III.2 from G.8273 Appendix III – SyncE Transient Input Pattern

Measurement Process

Confirm that preconfigured settings within the PTP Emulation app are appropriate for the current test scenario, as described in Section 4.4.

9.1 SyncE to 1pps Transient Response (Clause 7.4.1.2)

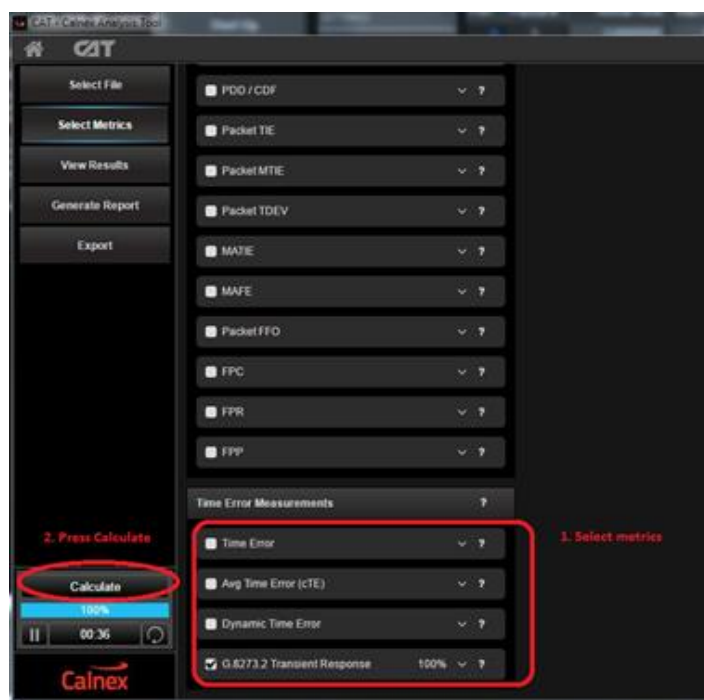
1. From the **Test:** drop-down menu, select **SyncE to 1pps Transient Response (Clause 7.4.1.2)**.
2. In the **Stimulus/Measurement** section, under **Measurement** ensure that **1pps Time Error** is selected.
3. From the **Generation** section of the conformance test app, press **Generate**. This starts PTP and ESMC message generation, allowing the device under test to stabilize. Pressing **Check** will open the **CAT** in a new tab to allow you to check the 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.



4. Once the DUT is stable, press **Stop** on the Check button then in the **Stimulus/Measurement** section press **Start** to start the 1pps measurement and application of the prescribed SyncE wander and ESMC state change stimulus.

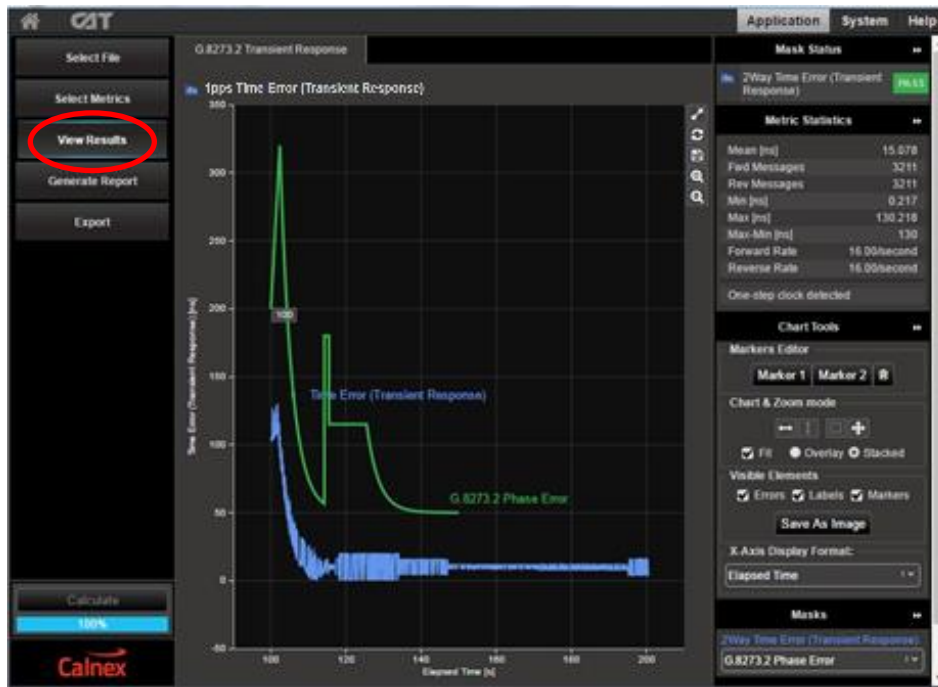
Test execution takes 200s. The first 100s are used to analyze the underlying Constant Time Error (cTE) without the application of the transient. As per the standard, the mask for Phase Noise response to the generated transient requires the results to be adjusted for cTE – this step, therefore, allows the CAT to calculate and make that adjustment.

5. On completion of the test, the test results can be analyzed using the CAT.
6. In the CAT, click on **Select Metrics** and enable the **G.8273.2 Transient Response** metric then click the **Calculate** button.



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.

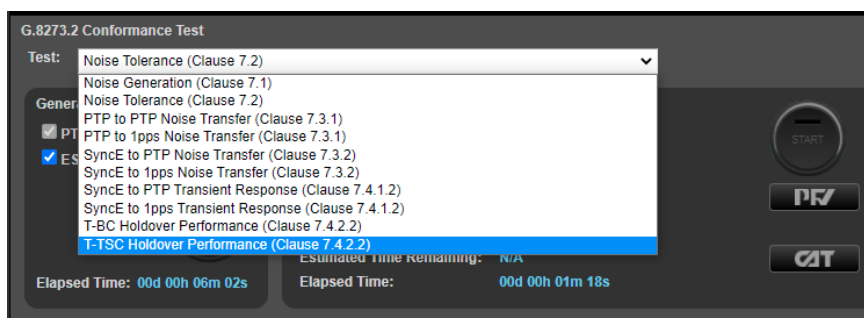
- Once the calculation has reached 100%, the results and associated Pass/Fail information can be viewed using the **View Results** button.



9.2 Holdover Performance

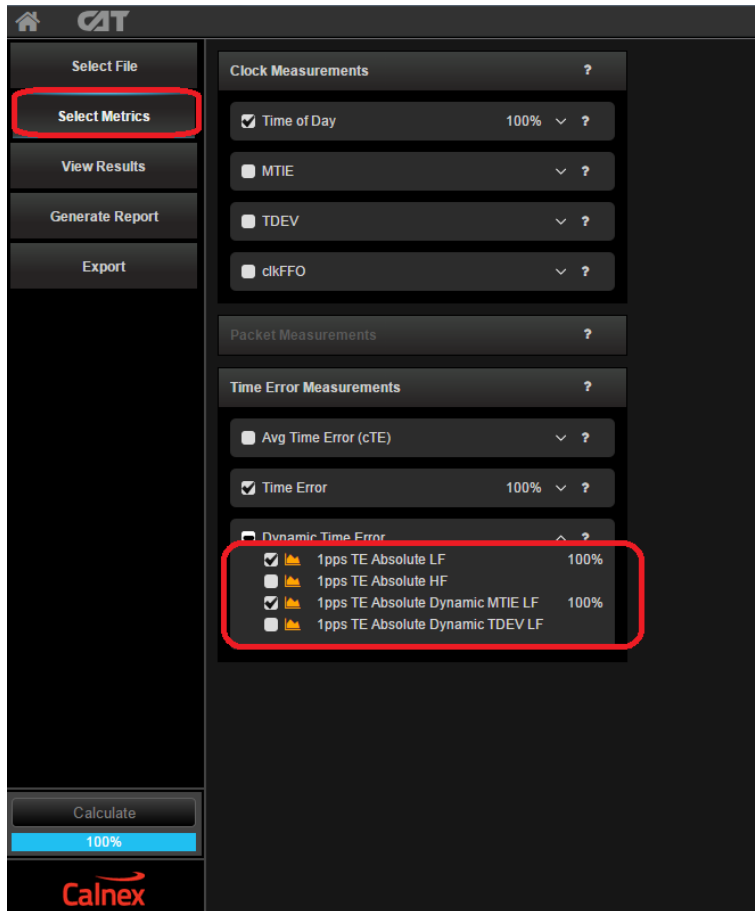
Holdover performance is checked by measuring the phase/time output in the event of the loss of the PTP input to the T-TSC.

- From the **Test:** drop-down menu, select **T-TSC Holdover performance (Clause 7.4.2.2)**.
- In the **Stimulus/M Measurement** section, under **Measurement** ensure that **1pps Time Error** is selected.
- From the **Generation** section of the conformance test app, press **Generate**. This starts PTP and ESMC message generation, allowing the device under test to stabilize. Pressing **Check** will open the **CAT** in a new tab to allow you to check the current timing performance. In this case, you should wait for a **1pps TE measurement** graph moving from a ramp to stable condition to indicate lock has been achieved.

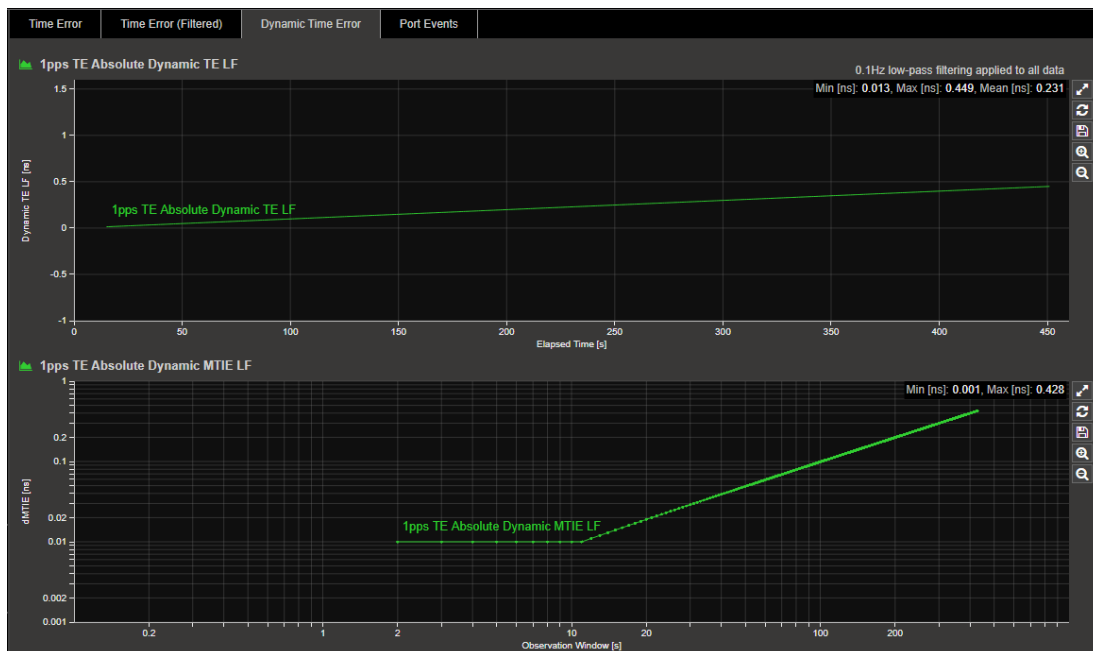


- Once the DUT is stable, press **Stop** on the Check button then in the **Stimulus/M Measurement** section press **Start** to start the 1pps measurement and simulate the loss of the PTP input signal to the device.
- On completion of the test, the test results can be analyzed using the CAT.

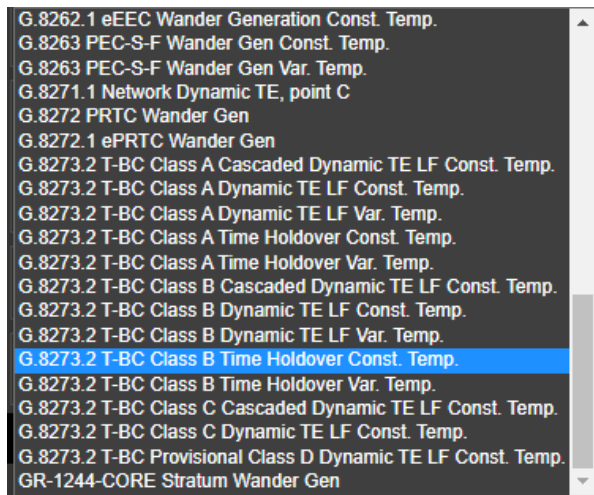
6. The key metrics to be examined are the **Dynamic TE LF** metrics. Enable these in the **Select Metrics** screen; for clarity, it is recommended to disable the Average Time Error (cTE) metrics and the other Dynamic TE metrics.



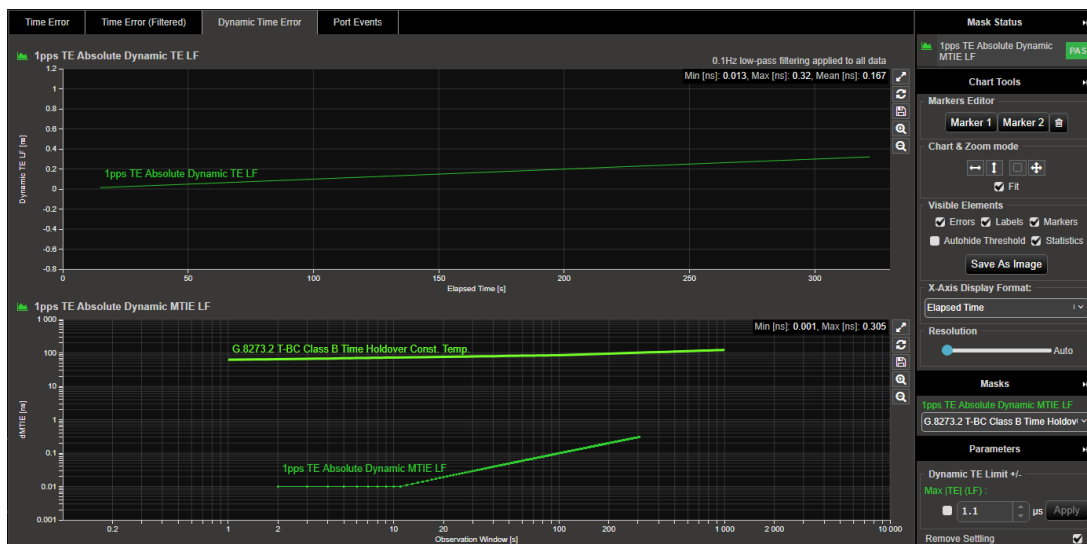
7. Select the **Dynamic Time Error** tab.



8. Select the particular **G.8273.2 T-BC Time Holdover Const Temp** mask relevant to the Class of device being tested, e.g.



9. Show results and check the Pass/Fail status.



Appendix 1 – Tests for a G.8273.2 T-TSC

Test	Objective	Test method	Output Limit (1pps signal)				
Time Error Noise Generation (G.8273.2, Clause 7.1)	With stable input references, measure the inherent time error (Max TE _L , Max TE _I , 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 ¹ .		Class A	Class B	Class C	Class D
			Max TE _L : ²	-	-	-	≤ 5ns
			Max TE _I : ³	≤ 100ns	≤ 70ns	≤ 30ns	FFS
			cTE:	≤ 50ns	≤ 20ns	≤ 10ns	FFS
			dTE _{LF} : ⁴	40ns MTIE, 4ns TDEV		10ns MTIE 2ns TDEV	FFS
			dTE _{HF} : ⁵	70ns p-p		FFS	FFS
Noise Tolerance (G.8273.2, Clause 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.	Combined PTP and SyncE tolerance: Apply Calnex noise tolerance pattern to the PTP input ⁶ . Simultaneously apply sine wave phase wander to the SyncE input according to G.8262, Table 9.	No output performance limit. Clock under test should not: <ul style="list-style-type: none">• generate alarms• switch reference• go into holdover				
Noise Transfer (G.8273.2, Clause 7.3)	Measures how time error on the input is transferred to the output. PTP-to-1pps transfer function: <ul style="list-style-type: none">• Low-pass filter (undefined order or shape)• Bandwidth from 0.05 to 0.1Hz SyncE-to-1pps transfer function: <ul style="list-style-type: none">• High-pass filter (undefined order or shape)⁷• Bandwidth from 0.05 to 0.1Hz	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. ¹	Tone frequencies and amplitudes defined in Appendix VI of G.8273.2 (Amd.1, 03/2020)				
		SyncE to 1PPS: Apply a stable time reference to the PTP input. Apply a set of sine wave phase modulations of 200ns p-p amplitude at several different frequencies.	Tone frequencies and amplitudes defined in Appendix VI of G.8273.2 (Amd.1, 03/2020)				

¹ 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.

² Max|TE_L| is calculated on time error data after low-pass filtering by 0.1Hz.

³ Max|TE_I| is calculated on the raw, unfiltered time error data.

⁴ MTIE and TDEV are calculated after low-pass filtering by 0.1Hz. Same values apply to both Class A and Class B devices.

⁵ TIE is measured after high-pass filtering by 0.1Hz. Same values apply to both Class A and Class B devices.

⁶ This pattern is derived from the dTE network limit MTIE mask, defined in G.8271.1 Figure 7-2.

⁷ Theoretically, this should be a band-pass filter with the low-pass cut-off between 1 and 10Hz, but since a 1pps interface can only carry frequencies of < 0.5Hz, it is effectively a high-pass filter.

Test	Objective	Test method	Output Limit (1pps signal)
Transients and Holdover (G.8273.2, Clause 7.4)	Measure the transient caused by a switch between PTP masters	No test method defined	No performance limit defined
	Measure the T-TSC response to a SyncE rearrangement transient.	<p>Apply a stable time reference to the PTP input.</p> <p>Apply a stable frequency reference to the SyncE input.</p> <p>After the T-TSC has locked onto the inputs and stabilised, apply the transient defined in G.8273 Figure III.2 to the SyncE input, coupled with changing the ESMC QL values at the times defined in G.8273 Appendix III.</p>	Phase mask defined in G.8273.2 Annex B
	Measures the response to entry into holdover caused by loss of packets at PTP input.	<p>Apply a stable time reference to the PTP input.</p> <p>Apply a stable frequency reference to the SyncE input.</p> <p>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.</p>	MTIE mask defined in G.8273.2, Table 7-7



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