

G.8273.4 Conformance Test

Testing Boundary and timeReceiver devices for Assisted Partial Timing Support and Partial Timing Support as per ITU-T G.8273.4 using Paragon-neo

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



To allow reliable synchronization distribution in networks using assisted partial timing support (APTS) and partial timing support (PTS) architectures, devices must have specific performance characteristics to deal with likely conditions in the packet network. ITU-T G.8273.4 specifies minimum requirements for time and phase synchronization equipment used in these environments.

This Test Guide shows how the Calnex Paragon-neo can be used to test T-BC-A, T-TSC-A, T-BC-P and T-TSC-P compliance as per G.8273.4 and provides procedures to measure noise generation, tolerance and transfer, 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-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.8275.2*	Emulation of G.8275.2 PTP devices, with associated Time Error Impairment and measurement capability
Opt. NEO-SyncE-Wander*	SyncE Wander and ESMC (optional depending on DUT functionality)
Opt. NEO-RTE*	PTP Testing – Relative Time Error
Opt. NEO-Background-Traffic	Background Traffic Generation (to test using ITU-T G.8273 methodologies)
Opt. NEO-ToD	Time of Day Testing – Generation and Measurement (if the DUT requires advanced setting of ToD signal settings for input, and/or measurement of the ToD output from the DUT is required.

*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

- Recommendation ITU-T G.8273.4 Timing characteristics of telecom boundary clocks and telecom time slave clocks for use with partial timing support from the network
- Recommendation ITU-T G.8275.2 Precision time protocol telecom profile for phase/time synchronization with partial timing support from the network
- Recommendation ITU-T G.8273 Framework of phase and time clocks
- IEEE Std 1588™ - 2008 IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
- IEEE Std 1588™ - 2019 IEEE Standard for a Precision Clock Synchronisation Protocol for Networked Measurement and Control Systems
- Calnex Application Note: Cabling Considerations (CX5009)
- Calnex Technical Guide: Partial Timing Support (PTS): *Testing G.8273.4 Clocks (CX6007)*
- Calnex Test Guide: *CX3016 Paragon-neo PRTC Test 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 behaviour 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.

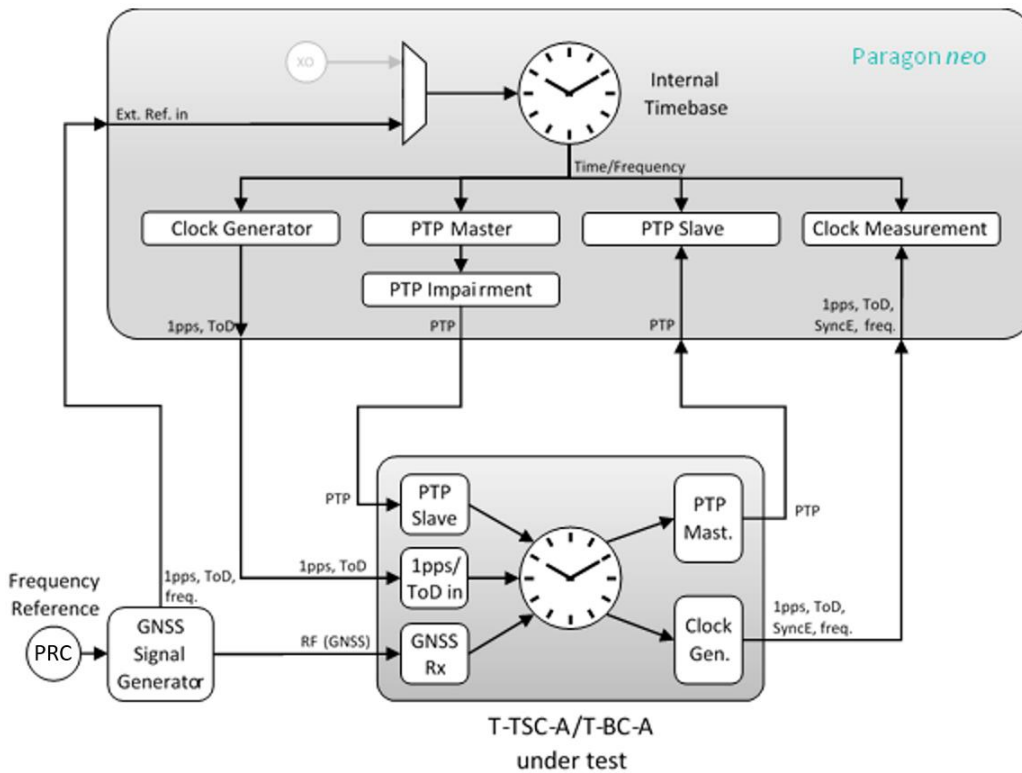
3 Connecting Paragon-neo to the Device-Under-Test

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.

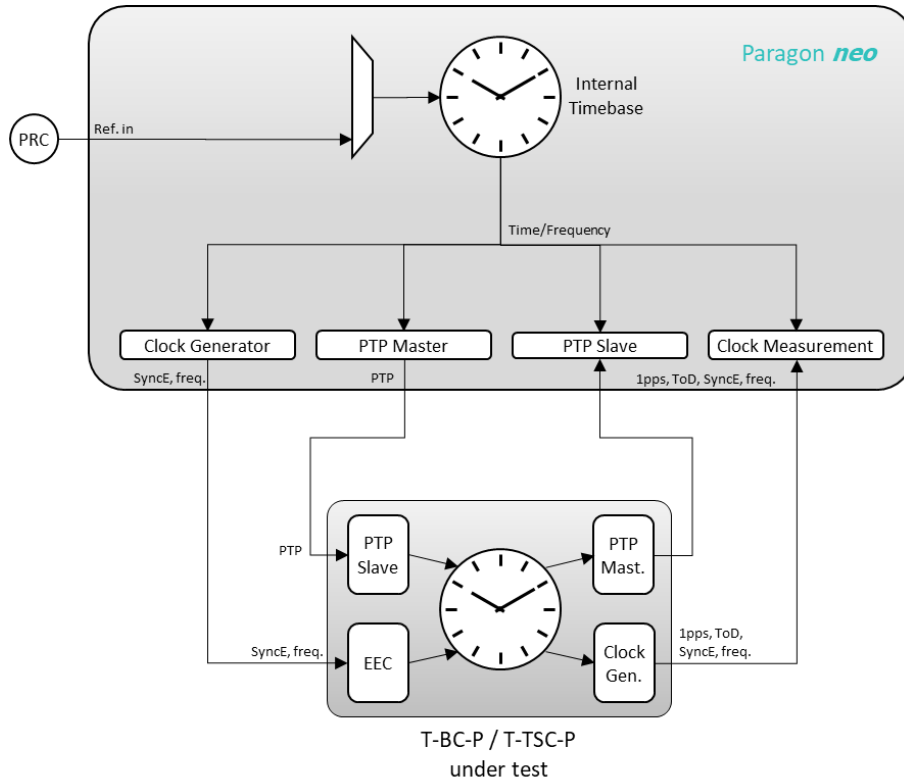
Whether the DUT implements Assisted Partial Support or Partial Timing Support will determine the specific physical connections to be made, both scenarios are shown in the diagrams below, with a description of the connections that apply to both configurations at the end.

Information regarding the Paragon-neo front panel connections and interface are detailed in the **Calnex Paragon-neo Getting Started Guide** that 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 Assisted Partial Timing support test configuration (T-BC-A and T-TSC-A):



3.2 Partial Timing support test configuration (for T-BC-P and T-TSC-P):



Connections

1. Connect Port 1 (timeTransmitter side of Paragon-neo) to the DUT timeReceiver side.
2. For T-BC-P testing, connect Port 2 (timeReceiver side of Paragon-neo) to the T-BC-P timeTransmitter side.
3. For testing PTS device-assisted holdover, a frequency or SyncE input to the DUT is required. If using frequency, connect the Paragon-neo Clock Ref Out port to the DUT; SyncE if required is on the already-connected Port 1.
4. Connect a PRC quality external frequency reference, e.g. Caesium-derived 10MHz, to the Paragon-neo Clock Reference Input.
5. If provisioned on the DUT, connect the 1PPS output from the DUT to the Paragon-neo 1PPS measurement port. This is required for T-TSC-P testing. Additional notes for this measurement are in the Transient and Holdover test sections of this document.
6. For testing APTS devices, the Paragon-neo Test Out 1PPS or 1PPS/ToD and/or an external GNSS RF signal (GNSS simulator required) should be connected to the appropriate DUT inputs. A 1PPS/ToD output from the device providing the GNSS RF signal should be connected to the Paragon-neo Reference Input.

4 Setting up the Paragon-neo for G.8273.4 Conformance Tests

The following steps are required to set up Paragon-neo prior to performing G.8273.4 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 the **PTP** operating mode preset.
4. If necessary, consult the Paragon-neo Getting Started Guide for more details.

4.2 Configuration of Physical Connections

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

The screenshot displays the physical connection configuration interface for the Paragon-neo. It features several sections for selecting reference and test ports, and a table at the bottom for configuring these connections.

References	Ethernet	Frequency Measurements	1pps / ToD Measurements	Test Out
Clock Reference Input Interface: BNC Signal: <input checked="" type="radio"/> 2.048MHz <input type="radio"/> 10MHz <input type="radio"/> E1 Use BNC 2.048MHz or 10MHz reference for high accuracy measurements. Termination: <input checked="" type="radio"/> 50 Ω <input type="radio"/> 75 Ω <input type="radio"/> High impedance			1pps + ToD Ref Input Interface: BNC Signal: 1pps Unbalanced Threshold (v): <input type="text" value="1.6"/> <input type="button" value="Apply"/> Termination: <input checked="" type="radio"/> 60 Ω <input type="radio"/> High impedance	1pps + ToD Ref Out Interface: BNC Signal: 1pps Unbalanced

4.3 Test Configuration

Select **Run Apps**, then, if prompted, the **PTP** preset.

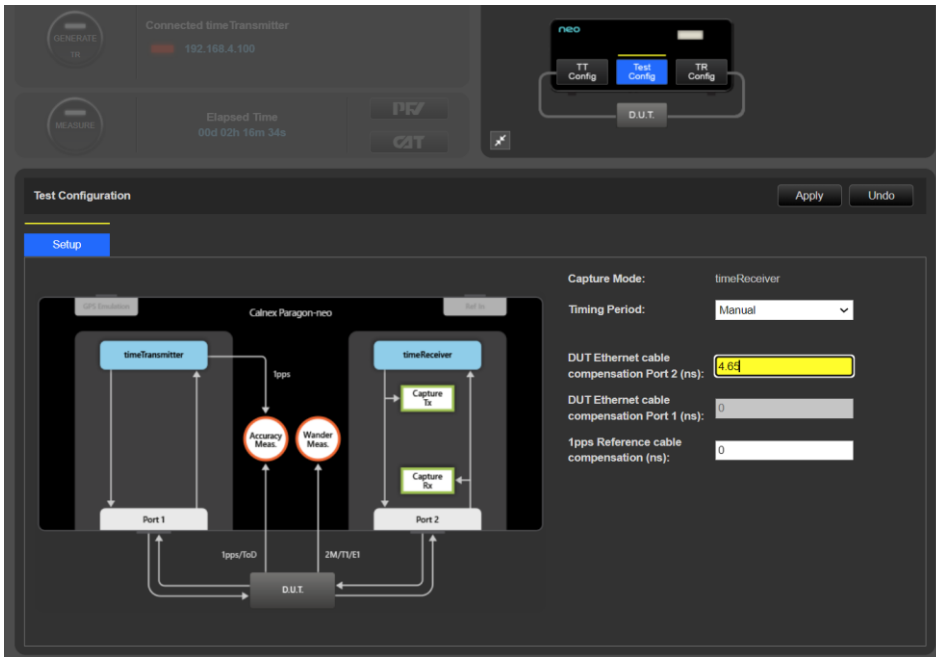


4.4 Device Connection Settings

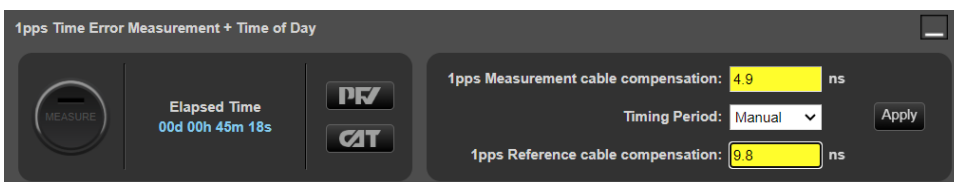
It is assumed that the G.8275.2 profile will be used in testing as per the G.8273.4 standard, and as a result testing will be carried out using UDP/IPV4/IPV6 encapsulation in Unicast mode. The Paragon-neo PTP Emulation can be configured to use other settings, e.g. Multicast L2 etc., however it should be noted that these do not conform to the requirements of the G.8273.4 standard.

1. In the **PTP Emulation** app, choose **PTP Profile** and select **G.8275.2 Phase Profile for PTS**. From **Test Mode**, select **Boundary Clock** or **timeReceiver** as appropriate for the DUT.
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. In the **PTP Emulation** app, choose **Test Config** and enter any relevant cable delay compensation settings in the **Test Configuration** page.

Delay values are entered in ns and should be entered to at least one decimal place for best performance. A value of 4.9ns per metre of Optical Fibre is typical but can vary by fibre type – for best performance it is highly recommended to confirm delay values with the fibre manufacturer. For coaxial cable, values of 4.5 to 5ns per metre of cable are typical; again, it is recommended to independently verify the cable delay. Once the required values have been set, click **Apply**.



4. If measuring a 1PPS signal, in the **1pps Time Error Measurement** app, enter the relevant cable delay compensation values.



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

5. If using a 1PPS/ToD reference from Paragon-neo into the DUT, in the **Time of Day Generation** app configure the Format, Event, Announce and GNSS settings to match those appropriate for the DUT.

The screenshot shows the 'Time of Day Generation' application interface. At the top left, there is a 'GENERATE' button and an 'Elapsed Time' display showing '00d 00h 00m 00s'. To the right, the 'Format' is set to 'G.8271', and three checkboxes are checked: 'Event', 'Announce', and 'GNSS'. Below this is the 'Message Settings' section, which includes an 'Apply' and 'Undo' button. A checkbox labeled 'Use settings from PTP Emulation configuration' is currently unchecked. Three tabs are visible: 'Event', 'Announce' (which is selected and highlighted in blue), and 'GNSS'. The 'Announce' tab contains the following configuration fields:

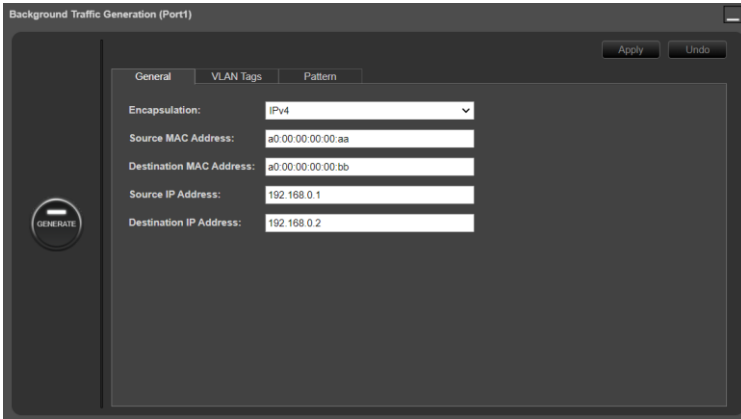
Domain:	24	Time Source:	GPS
Clock Identity:	00:00:00:00:00:00:01	Steps Removed:	0
Port Number:	00:01	<input type="checkbox"/> PTP Leap 59	
Priority 1:	128	<input type="checkbox"/> PTP Leap 61	
Priority 2:	128	<input checked="" type="checkbox"/> PTP Timescale	
Clock Class:	6	<input checked="" type="checkbox"/> Current UTC Offset Valid	
Clock Accuracy:	100 ns	<input checked="" type="checkbox"/> Time Traceable	
Log Variance:	ff:ff	<input checked="" type="checkbox"/> Frequency Traceable	
GM Clock Identity:	00:00:00:00:00:00:01		

4.5 Background Traffic

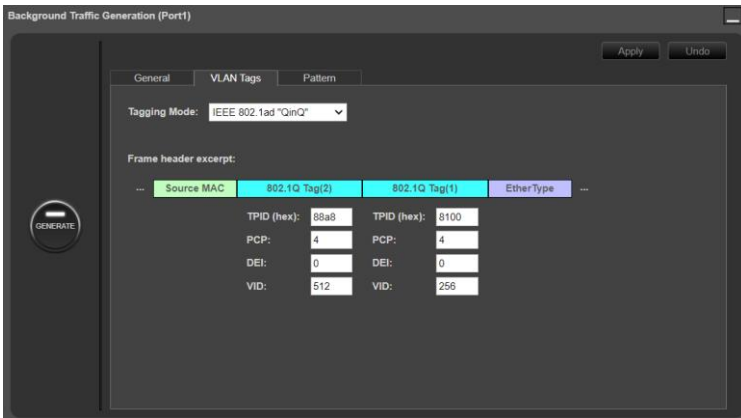
The measurement methodologies specified in ITU-T G.8273 Annex B include a requirement for traffic generation to introduce suitable loading on the ports of the DUT that carry the timing packets.

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.

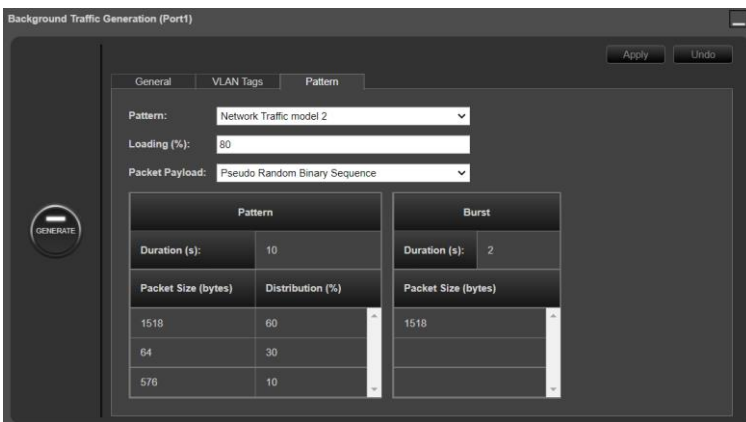
1. In the **Background Traffic Generation** app for the required Paragon-neo port, choose **General** and select the encapsulation, source and destination addresses for the generated traffic.



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

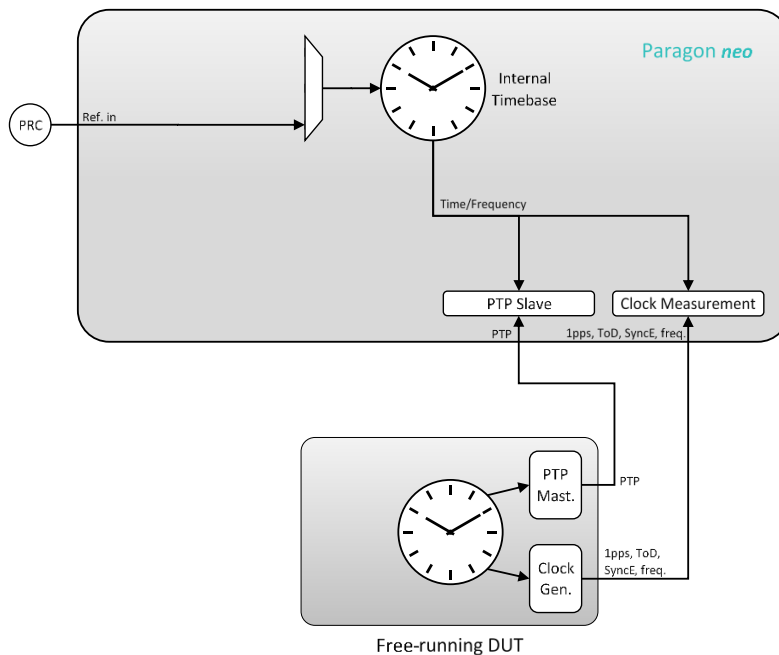


5 Frequency Accuracy for APTS Devices – G.8273.4 Clause 7.1

Test Description

The free-run frequency accuracy for a T-BC-A and T-TSC-A is measured after power-up of the DUT with all its input signals disconnected. The free-run frequency accuracy can be measured on the PTP output (for a T-BC-A), and on the 1PPS/ToD and telecom frequency outputs. The fractional frequency offset (FFO) should be **within 4.6ppm of the frequency of a PRC-traceable reference.**

G.8273.4 does not specify a timeframe for which the frequency accuracy is to be measured over, Calnex recommend testing for at least 10,000s however if the results are close to the limit, or if more confidence is required then a longer timeframe is recommended.

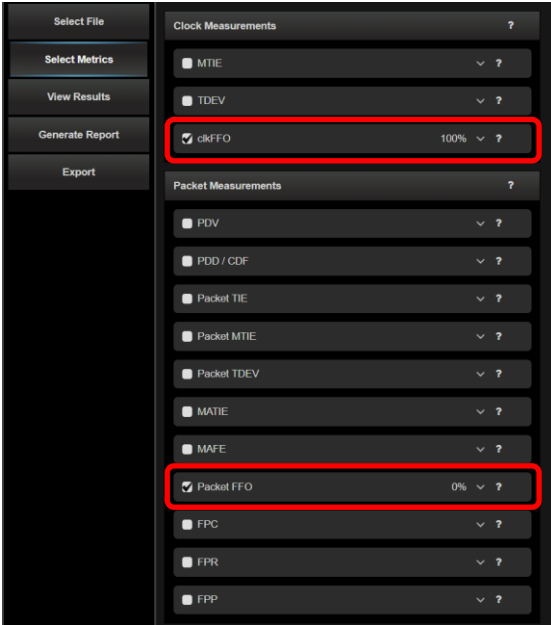


Measurement Process

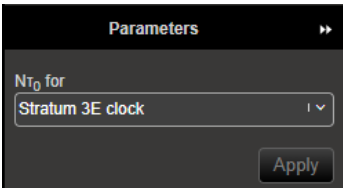
1. Ensure that the frequency reference to the Paragon-neo is of PRC quality.
2. If measuring the PTP output from a T-BC-A, confirm that preconfigured settings within PTP emulation are appropriate for the current test scenario, as described in Section 4.4. The **PTP Emulation** app should be configured in **timeTransmitter Test Mode**, as no PTP input will be provided to the DUT.
3. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.
4. From the **PTP Emulation** app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run. Selecting **Measure** then **CAT** will launch the Calnex Analysis Tool, allowing confirmation that the device timing output is stable and ready to test.
5. Once confident that the DUT is stable, **Stop** then **Start** the measurement again.
6. If measuring 1PPS and/or frequency, select **Measure** in the appropriate app(s) to start the measurement.
7. Let all measurements run for at least 10,000s.

Results Analysis

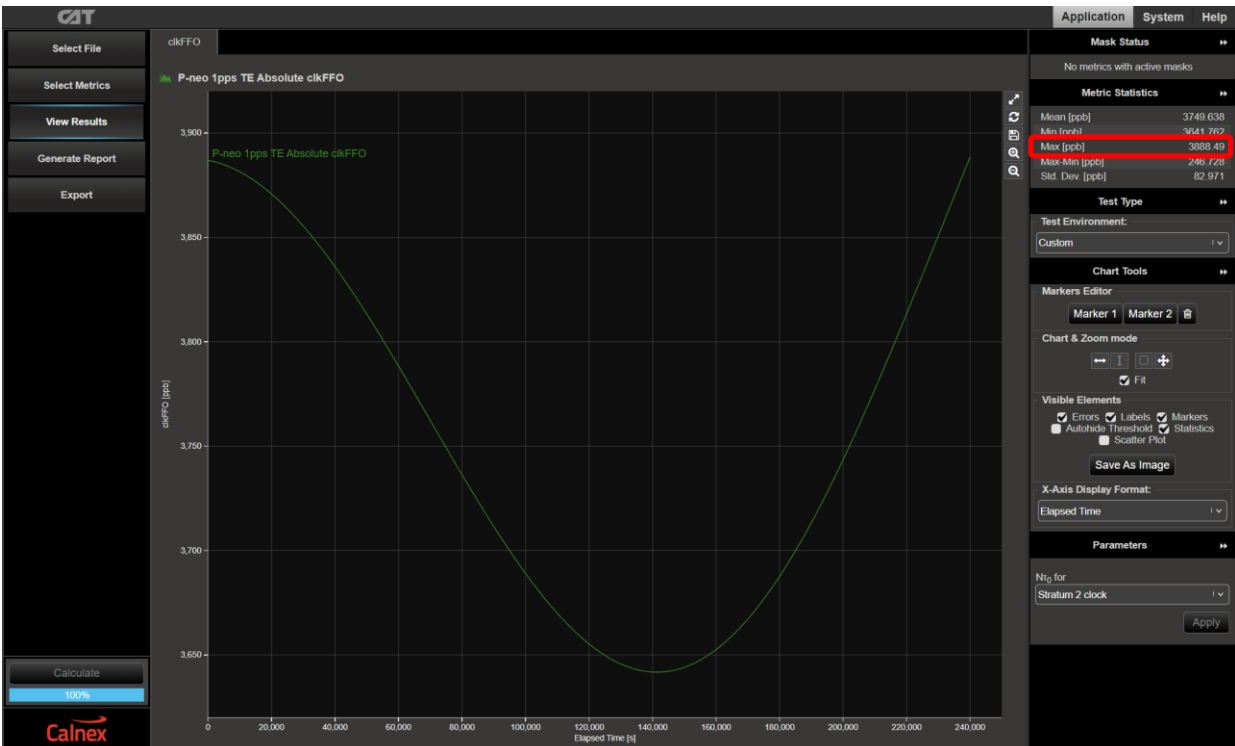
- In **CAT**, use the **Select Metrics** button to ensure **Packet FFO** has been enabled. If measuring 1PPS and/or Frequency, ensure **clkFFO** has been selected for these measurements. Deselecting all **Time Error Measurements** metrics is recommended to simplify observing the required results.



- For each FFO metric being tested, go to the appropriate tab, and select **Stratum 3E clock** in the Parameters section:



- For each FFO metric being tested ensure the **Max [ppb]** value as displayed in the top right of the packet FFO graph does not exceed 4600 (i.e. 4.6ppm).



6 Noise Generation for APTS devices – G.8273.4 Clause 7.2

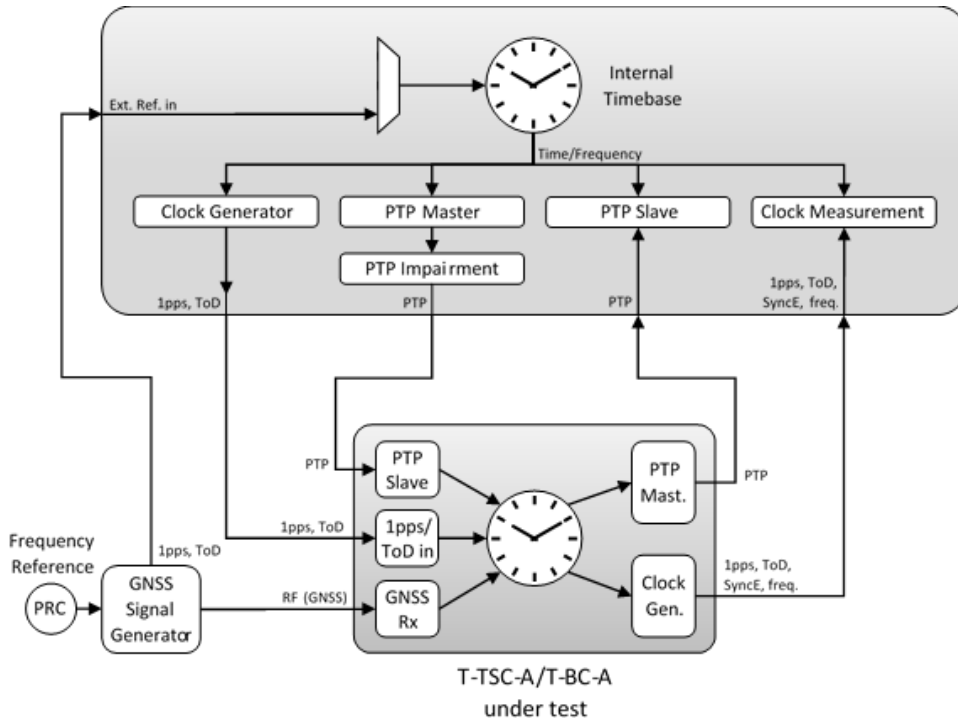
Test Description

The noise generation of a T-BC-A or T-TSC-A represents the amount of noise produced at the output of the device when there is an ideal input reference timing signal. For BCs, the output for test is PTP, with optional measurement of 1PPS if available. For TSCs, the output for test is 1PPS. The performance requirements are currently based on having a single time input and not multiple concurrent inputs.

For APTS devices, possible timing inputs are PTP, 1PPS and GNSS. Their noise generation has two defined components: constant time error (cTE) and dynamic low-pass filtered noise generation (dTE_L). There is no defined test limit specified when GNSS is the timing input, however the maximum absolute time error max|TE| performance is expected to be less than 100ns greater than the equivalent measurement with 1PPS as the reference. The table below summarizes the performance requirements.

DUT Class	Time Input	cTE	dTE _L peak-to-peak
Class A	1PPS	±50ns	50ns
	GNSS	–	–
	PTP	–	200ns
Class B	1PPS	±20ns	50ns
	GNSS	–	–
	PTP	–	200ns

Note: The 200ns for the PTP input case, although the dTE limits are not defined in the G.8273.4 (current status “for further study”) the specification can be inferred to be 200ns peak-to-peak from the holdover specification (see section 9).

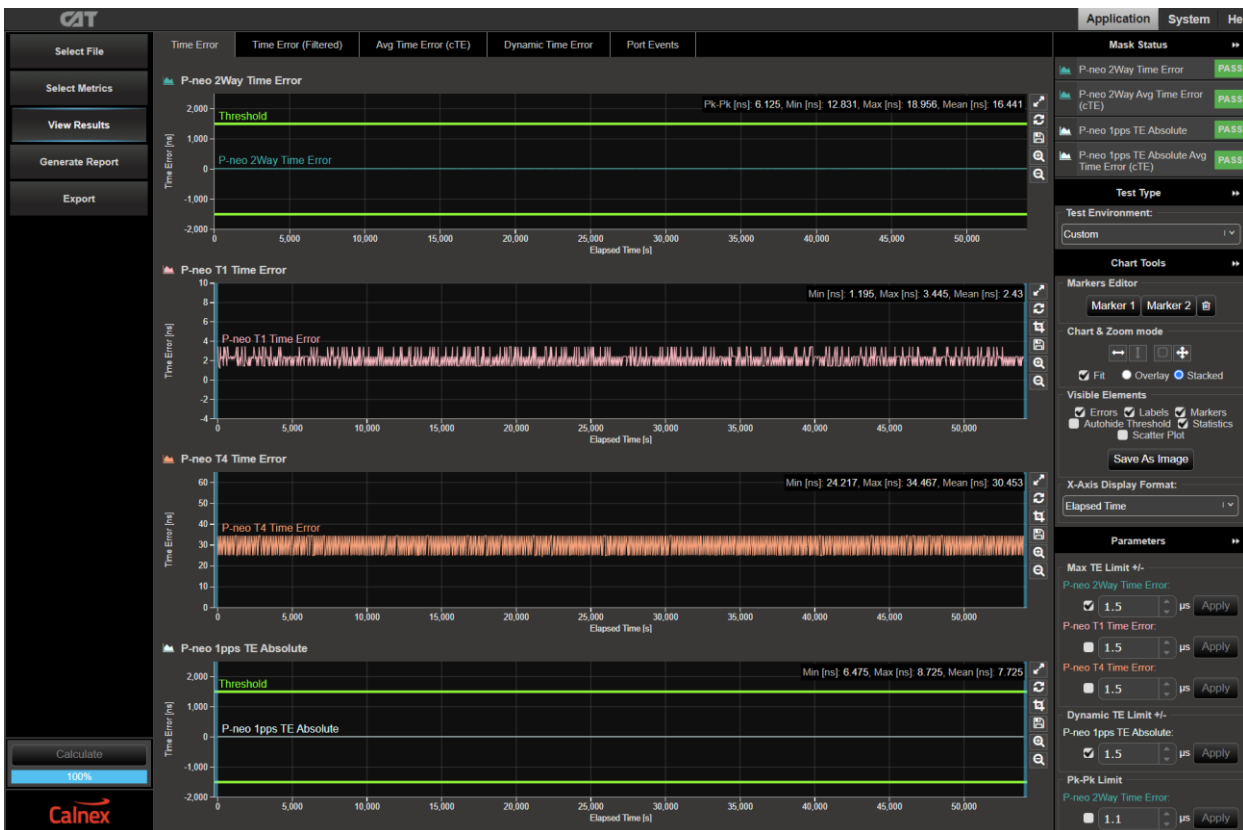


Measurement Process

1. **Note: for APTS devices, testing may need to be performed up to three times: once each with PTP, 1PPS or GNSS as the selected reference to the DUT (based on reference options configurable on the DUT).**

Although no limits are specified when the input is GNSS, as a common deployment scenario it is recommended to measure the equivalent metrics in this case for comparison. The GNSS input at this time can be sourced from a GNSS simulator or external antenna and be a 'clean' signal as received by a stationary antenna with a clear view of the sky.

2. Confirm that preconfigured settings within **PTP emulation** and, if required, **Time of Day Generation** are appropriate for the current test scenario, as described in Section 4.4.
3. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.
4. From the **PTP Emulation** app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run. Selecting **Measure**, then Selecting **CAT** will launch the Calnex Analysis Tool, allowing confirmation that the device timing output is stable and ready to test.
5. Once confident that the DUT is locked and stable, **Stop** then **Start** the measurement again, and allow to run for at least 10,000s for cTE and dTE measurements. Time Error results can either be viewed during a capture or after the capture has been stopped.
5. Select **CAT**. The Calnex Analysis Tool will open in a new browser tab displaying **Time Error** metrics.

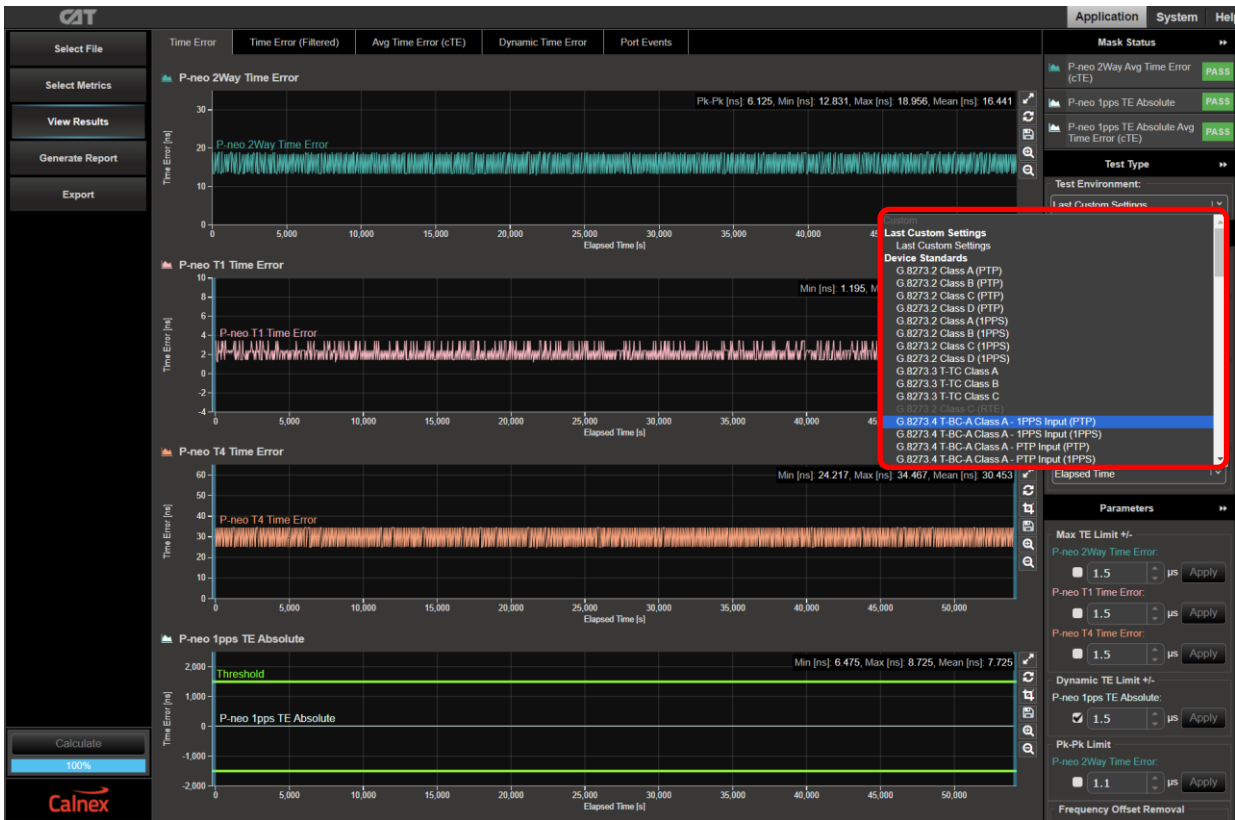


For PTP and 1PPS based data these will include the metrics **Time Error**, **Avg. Time Error (cTE)** and **Dynamic Time Error**.

Results Analysis

1. In CAT, select the appropriate **Test Environment** for the DUT class and output type.

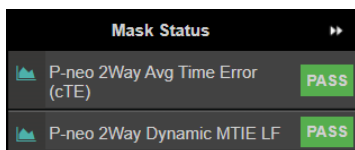
If both PTP and (optionally) 1PPS measurements have been completed, follow the steps below, including checking the Pass/Fail, then return to this step to set the environment for the other signal type.



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



- The device 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 (Optional)

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 (i.e. against the G.8275.2 profile for partial timing support). For further information please refer to the **PFV Getting Started Guide**.

7 Time Noise Tolerance for APTS devices – G.8273.4 Clause 7.3

Test Description

This test checks whether the equipment clock can maintain network limits at the output with maximum noise at the input. An APTS device uses its local time reference (usually GNSS) during normal operation and switches to a PTP input if the local time reference fails, applying compensation for any cTE caused by the network on the PTP input.

The noise tolerance of a clock indicates the minimum time error level at the input of the clock that should be accommodated while: **not causing any alarms; not causing the clock to switch reference; not causing the clock to go into holdover.**

Additionally, the outputs of the device must be within the limits in the table below, as defined in ITU-T G.8271.2 clause 7.4.1:

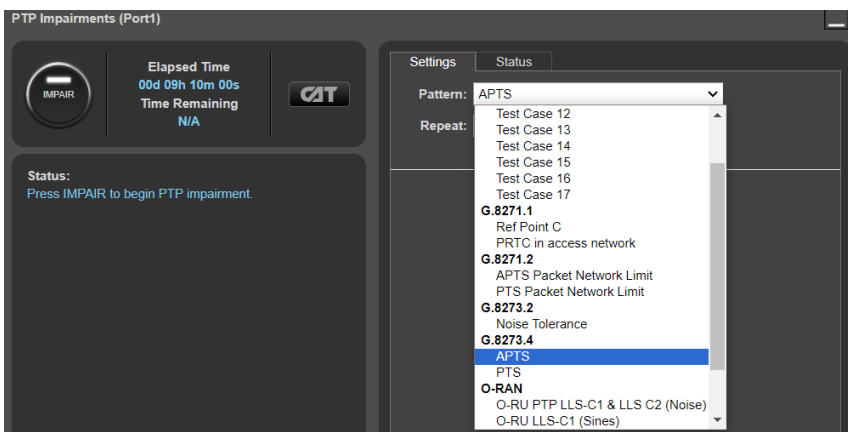
DUT Type	1PPS Output	PTP Output
T-BC-A	Max TE _L < 1.35µs	Max TE _L < 1.35µs
T-TSC-A	Max TE _L < 1.35µs	N/A

The level of noise that an APTS device must tolerate on its PTP input is peak-to-peak pktSelected2wayTE according to the network limit defined in ITU-T G.8271.2 clause 7.3.1.1. There is no specified tolerance requirement for SyncE wander for APTS devices. **ITU-T G.8273.4 Appendix VI** describes the methodology to generate a suitable PTP delay pattern for tolerance testing, a pattern conformant to this methodology is available for selection in the Paragon-neo **PTP Impairments** app, this pattern is 32,600s (9 hours) in duration and has a cTE of -12µs.

Appropriate noise types for a GNSS input are not defined and are out of the scope of this document however it is recommended to consider likely GNSS deployment scenarios and confirm DUT performance under these conditions. The Calnex Test Guide: *CX3016 Paragon-neo PRTC Test Guide* gives further information regarding testing of GNSS devices.

Measurement Process

1. Confirm that preconfigured settings within PTP emulation are appropriate for the current test scenario, as described in Section 4.4.
2. The DUT must be using its local time reference (usually GNSS) and configured to use the PTP backup input if the local time reference fails.
3. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.
4. From the **PTP Emulation** app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run.
5. From the **Pattern** drop-down menu in the **PTP Impairments** app, select the **G.8273.4 APTS** Pattern, and ensure that the **Repeat** option is set to **No**. Then select **Impair**.



While running, the **Status** tab will show progress through the impairment pattern; the current position within the pattern is indicated by the red bar.



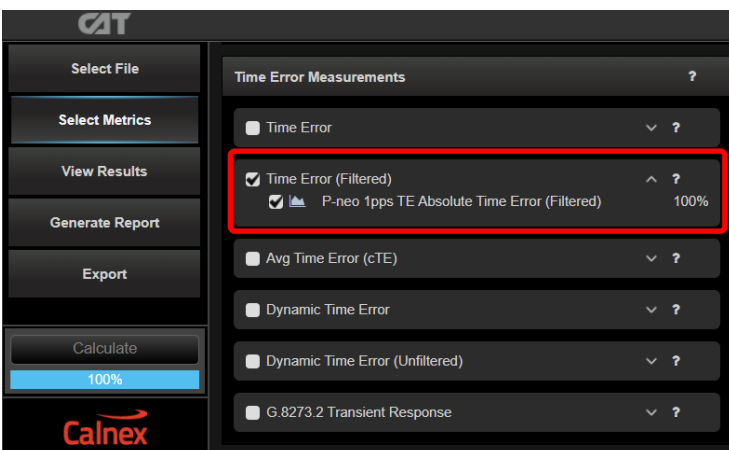
The DUT should now be given an appropriate amount of time to qualify the PTP input from the Paragon-neo and determine the cTE present in the impairment pattern. There are no conformance requirements regarding the amount of time this should take, however up to 30 minutes is reasonable.

6. When the DUT is correctly compensating for the cTE and has stabilized, continue this procedure.
7. If the DUT is a T-BC-A, in the **PTP Emulation** app, select **Measure**.
8. If the DUT has a 1PPS output, in the **1pps Time Error Measurement + Time of Day** app selecting **Measure**.
9. Selecting **CAT** within either the **PTP Emulation** or **1pps Time Error Measurement + Time of Day** apps will launch the Calnex Analysis Tool where the performance of the DUT outputs can be monitored.
10. The DUT must now be forced to select the PTP input as its reference, for example by disconnecting the GNSS antenna. This step may **raise alarms** related to the removed reference, and the DUT will **switch reference** to PTP, however, these outcomes are expected and should be ignored.
11. Selecting **CAT** within either the **PTP Emulation** or **1pps Time Error Measurement + Time of Day** apps will launch the Calnex Analysis Tool where the performance of the DUT outputs can be monitored.
12. Monitor the DUT to confirm it has not raised alarms, switched reference, or entered holdover.
13. Monitor the **Time Remaining** indicator on the **PTP Impairments** app, when the indicator stops counting down **Stop** the running measurement(s).

Results Analysis

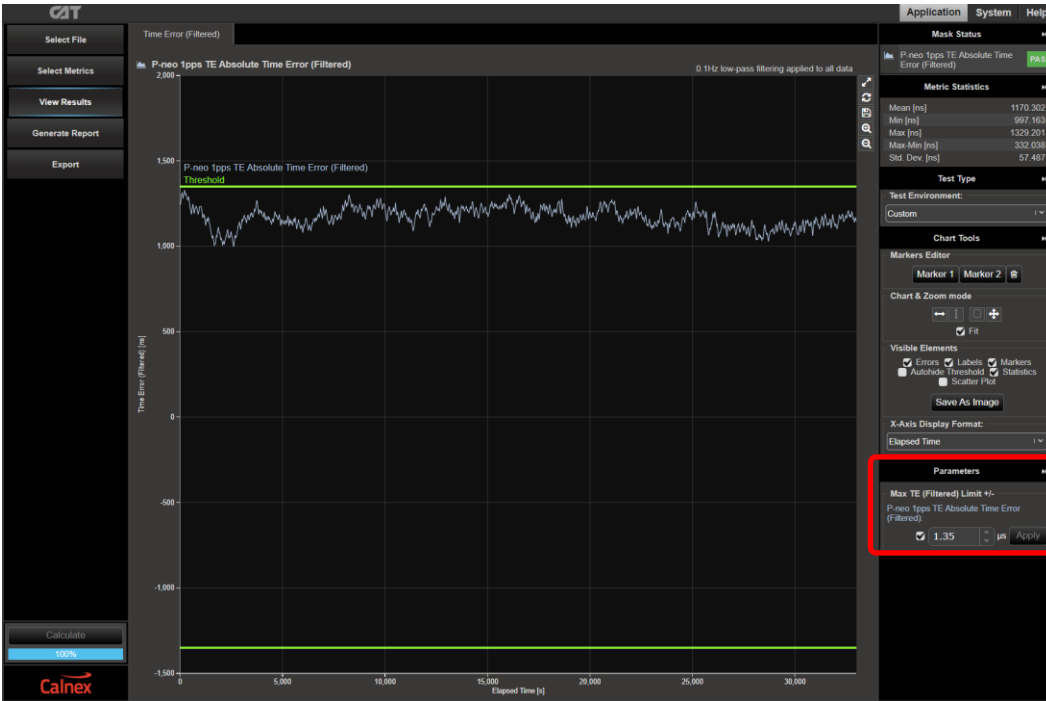
1. In **CAT**, click **Select Metrics** and ensure the required **Time Error (Filtered)** plots are checked for PTP and 1PPS, then press **Calculate**. The available metrics will depend on the configured measurements.

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

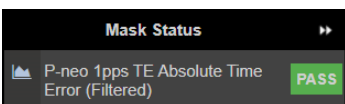


- Select **View Results** then select the **Time Error (Filtered)** tab. Set the **Max TE (Filtered) Limit** to the following as per the ITU-T G.8273.4 requirement for each available measurement and ensure that the checkbox is set to checked to apply the threshold.

DUT Class	Max TE (ns)	Max TE (Filtered) Limit (μ s)
Class A or B	1350	1.35



- The T-BC-A performance meets requirements when the output is within the applied threshold. The Pass/Fail status is indicated in the **Mask Status** block in the top-right area of the CAT display.

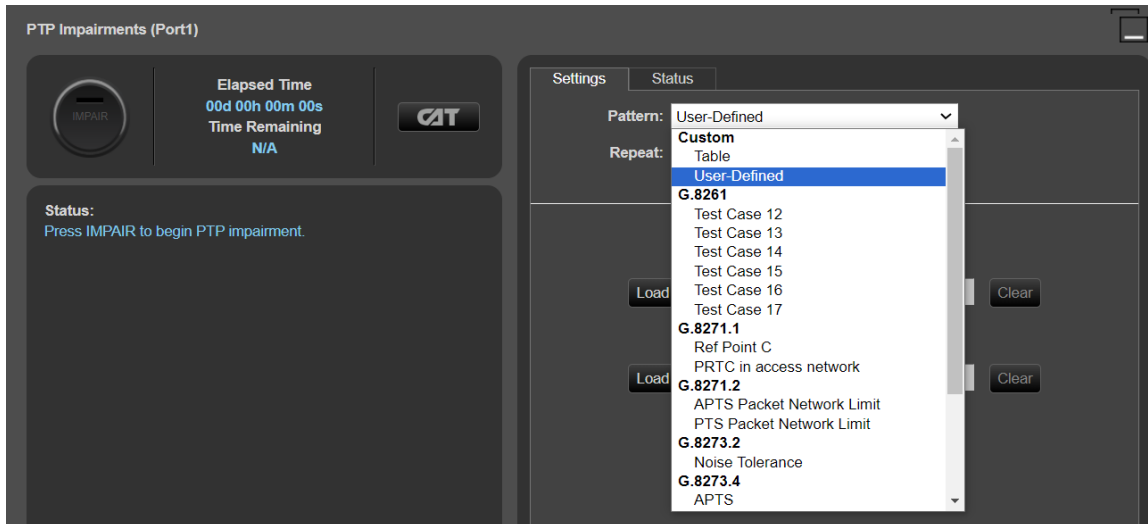


- Review the status and error logs of the DUT if they are available to confirm it has not any raised any alarms, switched reference, or entered holdover during the timeframe that it was using the PTP input.

Further Analysis (Optional)

As there will be many different deployed network topologies and traffic conditions for PTS and APTS networks, where possible it is recommended to capture real network Time Error patterns and perform the testing above using these patterns as the impairment to verify that DUT performance is as expected in real-world environments. Paragon-neo is capable of replaying Time Error patterns such as those captured using **Paragon-x** or the **Calnex Sentinel** field tool.

To replay a captured file, select **User Defined** in the **PTP Impairments > Pattern** drop-down list.



Selecting **Load** will open File Explorer to allow the selection and loading of any suitable file onto Paragon-neo.

8 Time Noise Transfer for APTS devices – G.8273.4 Clause 7.3

Test Description

In the passband, the phase gain of the DUT should be smaller than 0.1 dB (1.1%).

Measurement Process

There is no bandwidth specified for these types of clocks, and only the maximum phase gain of 0.1dB is specified. This means that the clock should not amplify any noise on its inputs by more than 0.1dB.

Since there is no bandwidth specification, it is not possible to define a deterministic test for the transfer specification. Further, 0.1dB is far less than the permitted noise generation and therefore cannot be observed in practice.

This specification should be viewed not as a testable requirement but rather as an indication to the designer that amplifying noise present on the input signal is not permitted.

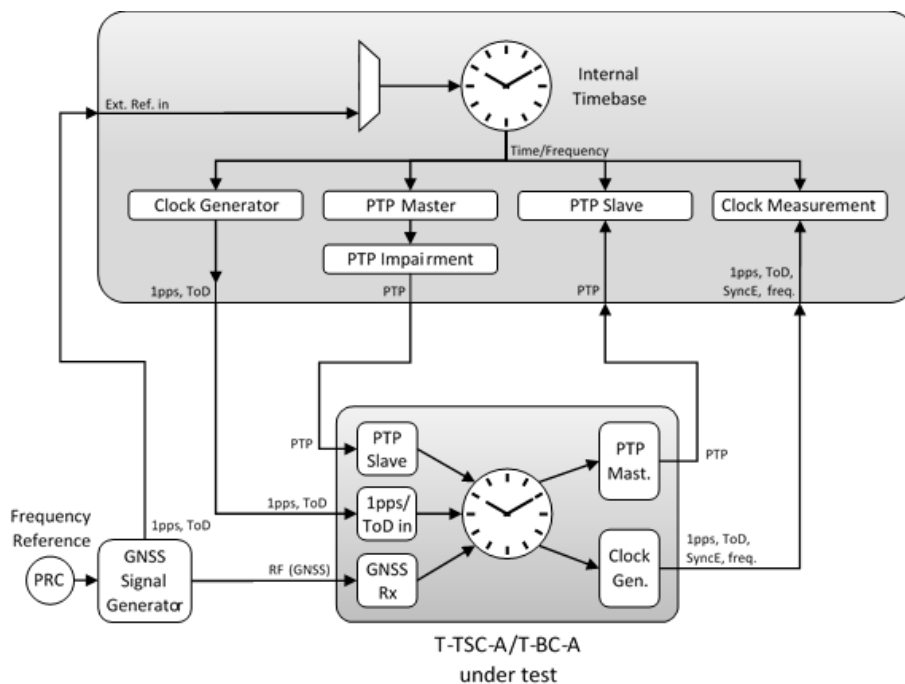
9 Transient Response and Holdover Performance for APTS devices – G.8273.4 Clause 7.5 and 7.6

Test Description

The transient response specifies the maximum size in the transient on loss or restoration of the local time reference. The holdover performance specifies the clock drift upon loss of references. The masks cover both the transient and holdover aspects for the relevant tests.

Performance is specified for two scenarios:

1. Loss of all references to the DUT, holdover is based on the local oscillator. This scenario has an allowance for an initial transient of 22ns followed by a drift to 1.0278µs over the subsequent 1000s and a 22ns transient when exiting holdover.
2. The DUT has a PTP reference available. This scenario has an MTIE limit of 222ns to cover the 22ns transient when entering holdover, 200ns maximum excursion during the subsequent 1000s, and a 22ns transient when exiting holdover.



Measurement Process

1. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.
2. Confirm that preconfigured settings within **PTP emulation** and, if required, **Time of Day Generation** are appropriate for the current test scenario, as described in Section 4.4.
3. Follow the steps in the sections below.

9.1 Phase Transient and Holdover based on a local oscillator (Clause 7.5 & 7.6.1)

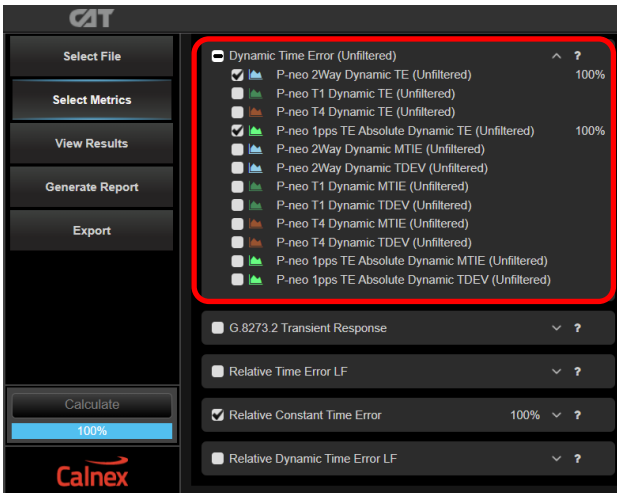
Note: The G.8273.4 clause 7.6.1 defines the permissible phase error in terms of Delta T (TIE). This definition accounts for the 22ns transients at entry and exit of holdover and is available as a **CAT** mask. Only 1PPS and PTP signal types have transient performance requirements.

1. Ensure all required references are connected to the DUT, if required start the external GNSS RF or, if using the Paragon-neo 1PPS/ToD reference, select **Generate** on the Time of Day Generation App.

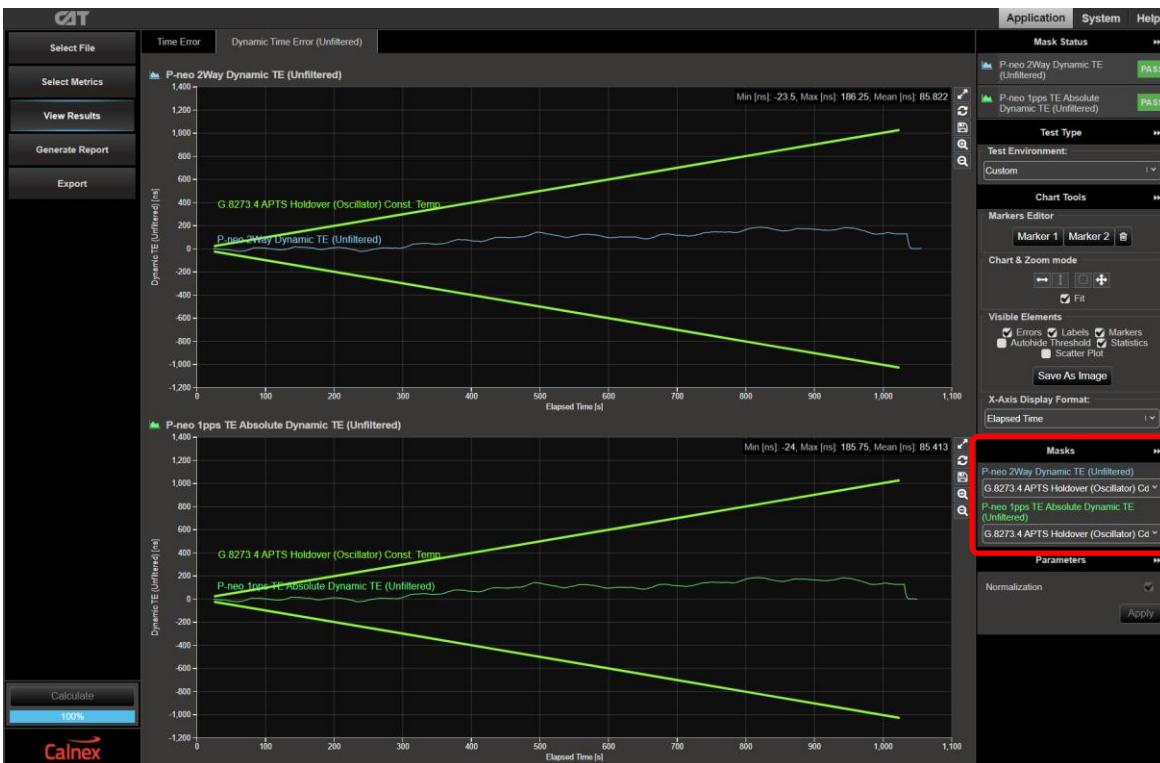
2. Select **Measure** on the relevant measurements (i.e. PTP, 1PPS) then select **CAT** to launch the Calnex Analysis Tool, verifying that the device timing output is stable and ready to test – this may take up to one hour, dependent on the DUT, once the device is stable **Stop** all measurements.
3. Select **Measure** on the relevant measurements then remove all reference sources from the DUT by e.g. removing cables.
4. Allow the measurement to continue for 1000s then reconnect the local time reference (GNSS or 1PPS/ToD) only i.e. do not reconnect any PTP input. Wait for the DUT to lock to the local time reference, then **Stop** the measurement.

Results Analysis

1. Select **CAT** to launch the Calnex Analysis Tool. In **CAT**, use the **Select Metrics** button. Ensure **Time Error** and **Dynamic Time Error (Unfiltered)** have been enabled. It is recommended to only select the following **Dynamic Time Error (Unfiltered)** metrics to simplify observing the results:



2. In **CAT** select the **Dynamic Time Error (Unfiltered)** tab and apply the **G.8273.4 APTS Holdover (Oscillator) Const. Temp.** mask to all measurements.

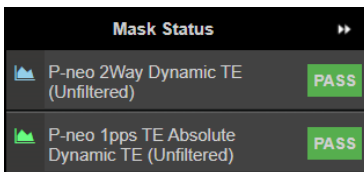


- If there is a noticeable transient in the plot when the reference to the DUT was removed, then this should be aligned with the start of the of the mask. If there is no visible transient then the start of the mask should be aligned with the point that the PTP reference to the DUT was removed.

To adjust the start point of the mask, select the **Time Error** tab and adjust the Data Analysis Range values to align the start of the mask with the start of that event. This can be performed by manually entering the values, or by click and dragging the blue start of plot marker. The mask in the dTE (Unfiltered) tab will auto-adjust to maintain its symmetry with the first measurement value in the selected range, if **Coupled Ranges** is checked (the default setting) then the same analysis range will be applied to all measurements.



- Select the **Dynamic Time Error (Unfiltered)** tab. The device 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:

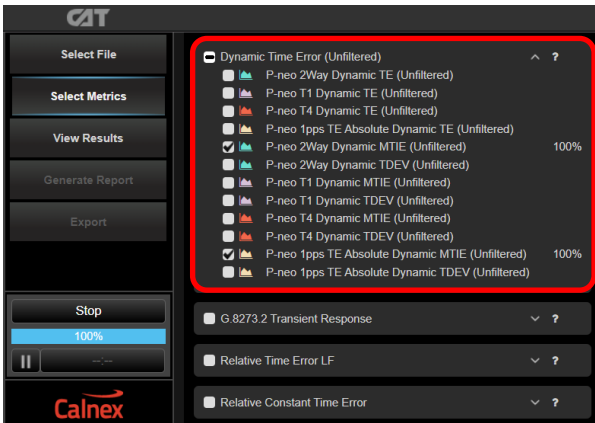


9.2 Phase Transient and Holdover based on PTP (Clause 7.5 & 7.6.2)

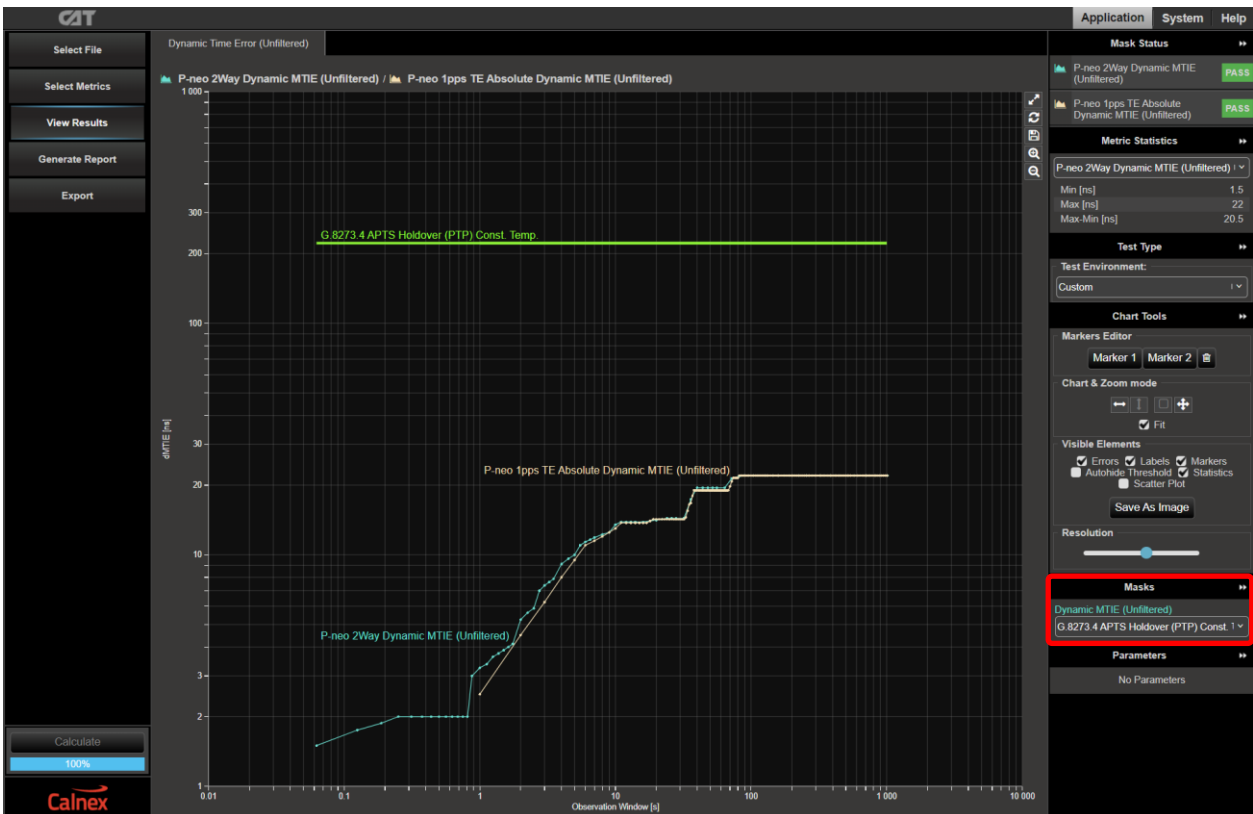
- From the PTP Emulation app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run.
- Select **Measure** on the relevant measurements (i.e. PTP, 1PPS) then select **CAT** to launch the Calnex Analysis Tool, verifying that the device timing output is stable and ready to test – this may take up to one hour, dependent on the DUT, once the device is stable **Stop** all measurements.
- Select **Measure** for the signal(s) that are being measured, then remove the local time reference (e.g. GNSS or 1PPS) only from the DUT by, e.g. removing the cable.
- Confirm the PTP input is selected as the reference by the DUT. Allow the measurement to continue for 1000s then reconnect the local time reference. Wait for the DUT to lock to the local time reference then **Stop** the measurement.

Results Analysis

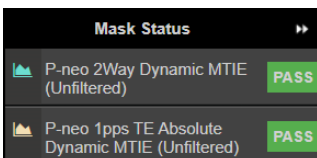
1. Select **CAT** to launch the Calnex Analysis Tool. In **CAT**, use the **Select Metrics** button. Ensure **Time Error** and **Dynamic Time Error (Unfiltered)** have been enabled. It is recommended to only select the following **Dynamic Time Error (Unfiltered)** metrics to simplify observing the results.



2. In **CAT** select the **Dynamic Time Error (Unfiltered)** tab and apply the **G.8273.4 APTS Holdover (PTP) Const. Temp.** mask.



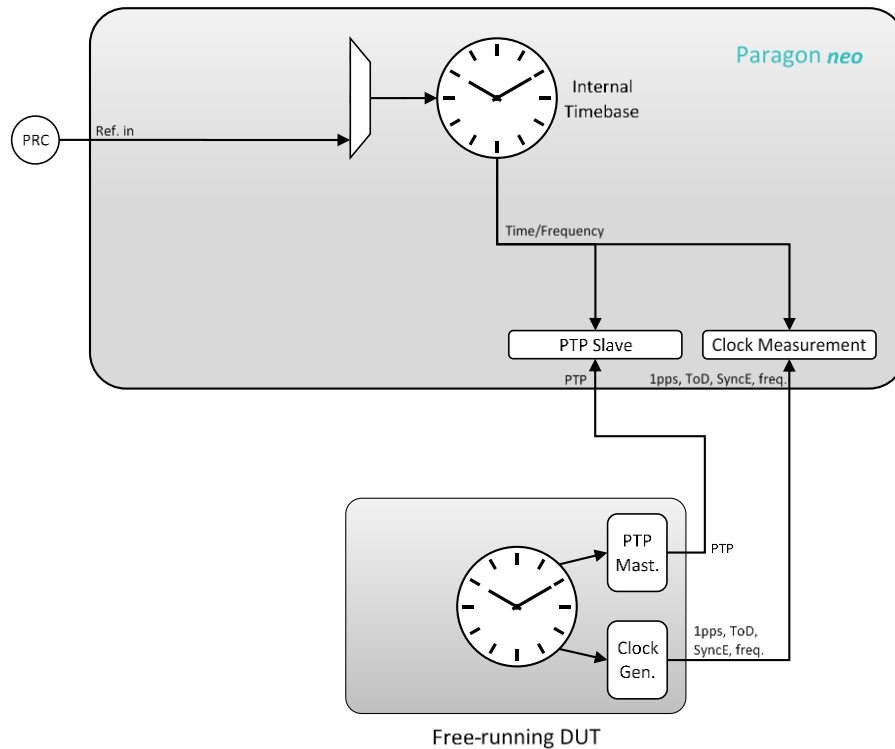
3. Select the **Dynamic Time Error (Unfiltered)** tab. The device performance meets requirements when the output is within the applied mask. The Pass/Fail status is indicated in the **Mask Status** block in the top-right area of the CAT display:



10 Frequency Accuracy for PTS Devices – G.8273.4 Clause 8.1

Test Description

The free-run frequency accuracy for a T-BC-P and T-TSC-P is measured after power-up of the DUT with all its input signals disconnected. The free-run frequency accuracy can be measured on the PTP output (for a T-BC-P), and on the 1PPS/ToD and telecom frequency outputs. The fractional frequency offset (FFO) should be within 4.6ppm of the frequency of a PRC-traceable reference.

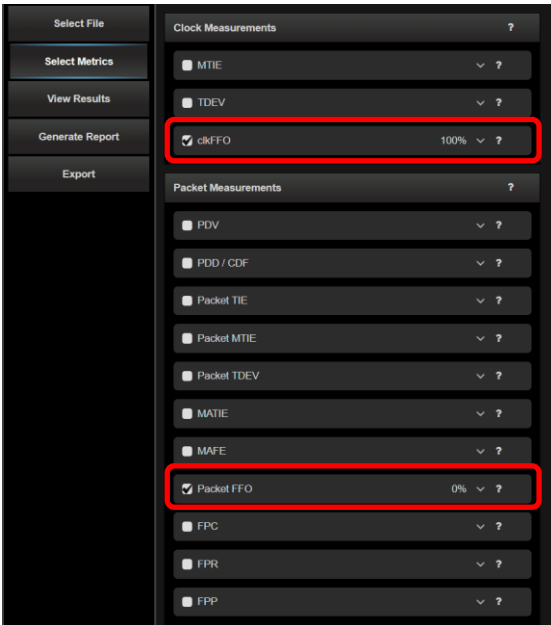


Measurement Process

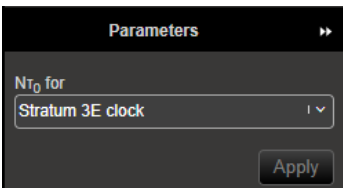
1. Ensure that the frequency reference to the Paragon-neo is of PRC-quality.
2. If measuring on the PTP output from a T-BC-P, confirm that preconfigured settings within PTP emulation are appropriate for the current test scenario, as described in Section 4.4. **PTP Emulation** app should be configured in **timeTransmitter Test Mode**, as no PTP input will be provided to the DUT.
3. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.
4. From the **PTP Emulation** app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run. Selecting **Measure** then Selecting **CAT** will launch the Calnex Analysis Tool, allowing confirmation that the device timing output is stable and ready to test.
5. Once confident that the DUT is locked and stable, **Stop** then **Start** the measurement again.
6. If measuring 1PPS and/or frequency, select **Measure** in the appropriate app to start the measurement.
7. Let all measurements run for at least 10,000s.

Results Analysis

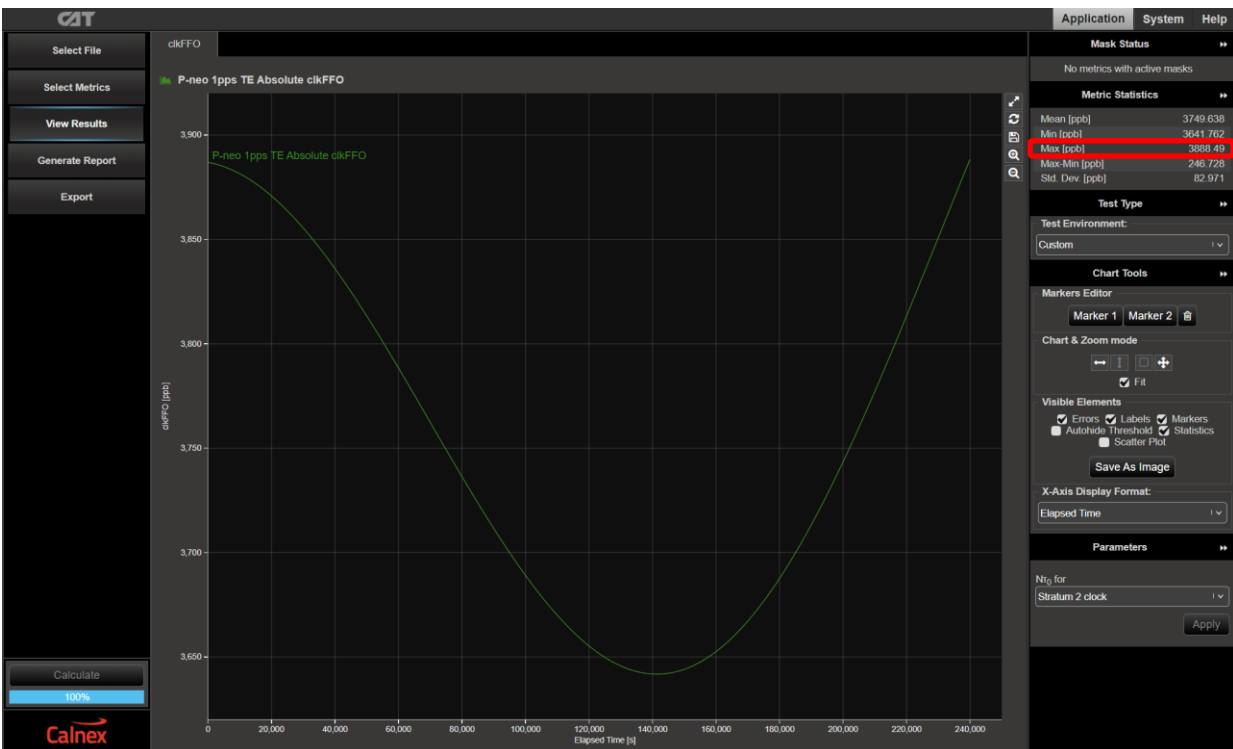
- In **CAT**, use the **Select Metrics** button to ensure **Packet FFO** has been enabled. If measuring 1PPS and/or Frequency, ensure **clkFFO** has been selected for these measurements. Deselecting all **Time Error Measurements** metrics is recommended to simplify observing the required results.



- For each FFO metric being tested, go to the appropriate tab, and select **Stratum 3E clock** in the Parameters section:



- For each FFO metric being tested ensure the **Max [ppb]** value as displayed in the top right of the FFO graph does not exceed 4600 (i.e. 4.6ppm).



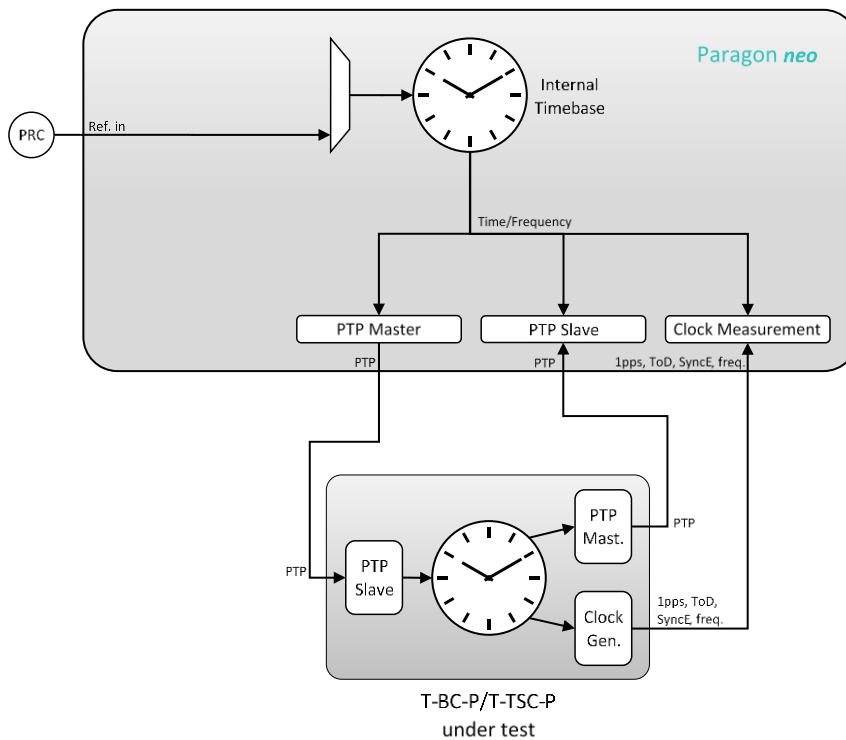
11 Noise Generation for PTS Devices – G.8273.4 Clause 8.2

Test Description

The noise generation of a T-BC-P or T-TSC-P represents the amount of noise produced at the output of the device when there is an ideal input reference packet timing signal. In the case of PTS devices, this is PTP. The noise generation has two defined components: constant time error (cTE) and dynamic low-pass filtered noise generation (dTE_L).

The table below summarizes the performance requirements.

DUT Class	cTE	dTE _L peak-to-peak
Class A	±50ns	200ns
Class B	±20ns	200ns

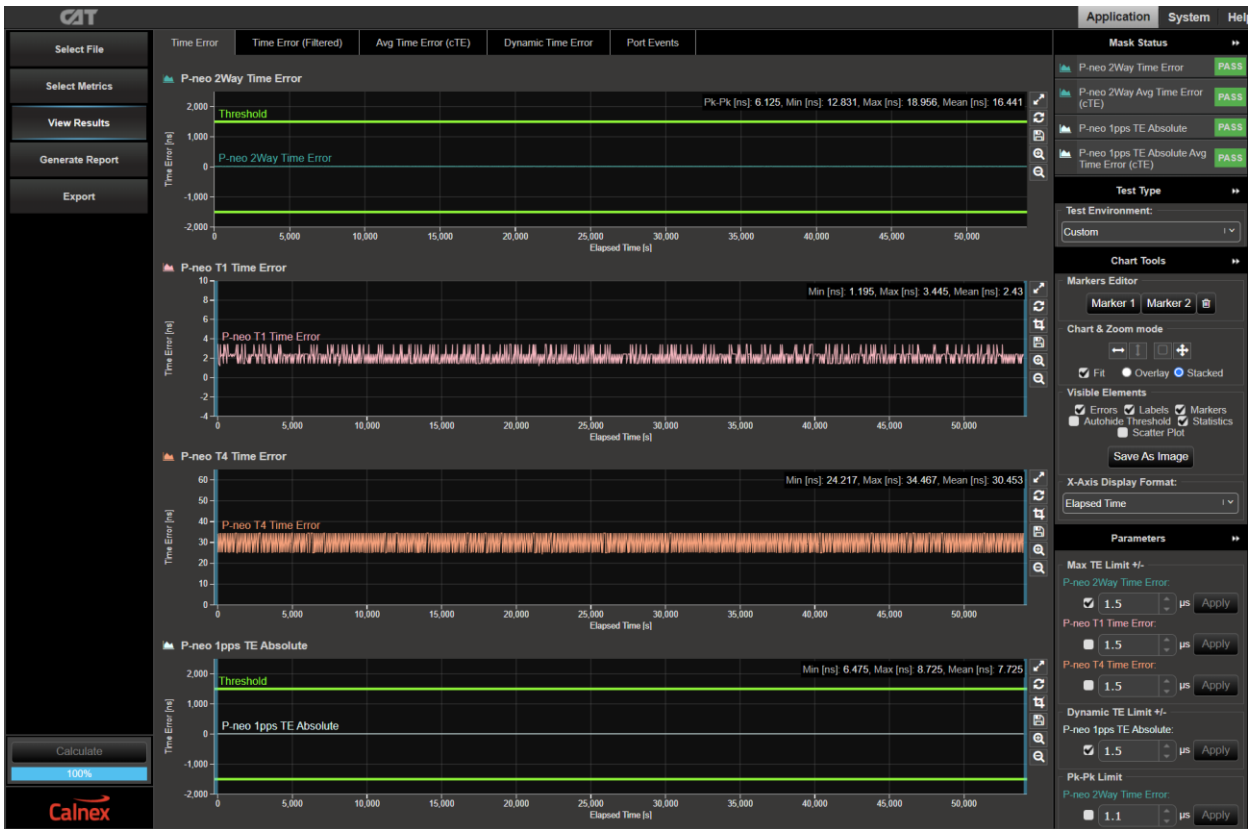


Measurement Process

1. Confirm that preconfigured settings within PTP emulation 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 **PTP Emulation** app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run. Selecting **Measure** then Selecting **CAT** will launch the Calnex Analysis Tool, allowing confirmation that the device timing output is stable and ready to test.
4. Once confident that the DUT is locked and stable, **Stop** then **Start** the measurement again, and allow to run for at least 10,000s for cTE and dTE measurements.

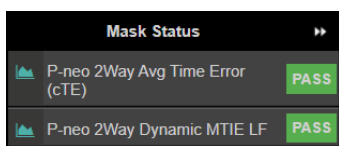
Measurements: Time Error results can either be viewed during capture or after capture has been stopped.

5. Select **CAT**. The Calnex Analysis Tool will open in a new browser tab displaying Time Error metrics.



For PTP and 1PPS based data these will include the metrics **Time Error**, **Avg. Time Error (cTE)** and **Dynamic Time Error**.

- The device 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 (Optional)

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**.

12 Time Noise Tolerance for PTS devices – G.8273.4 Clause 8.3

Test Description

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

The noise tolerance of a clock indicates the minimum time error level at the input of the clock that should be accommodated while: **not causing any alarms; not causing the clock to switch reference; not causing the clock to go into holdover.**

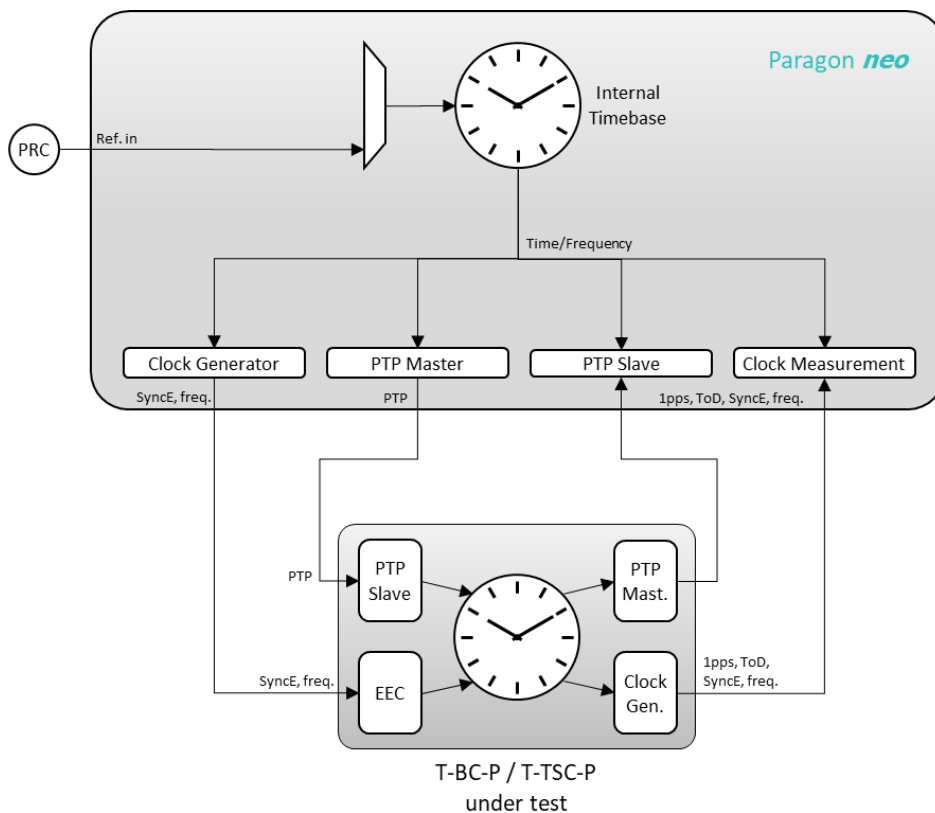
Additionally, the outputs of the device must be within the limits in the table below, as defined in ITU-T G.8171.2 clause 7.4.2:

DUT Type	1PPS Output	PTP Output
T-BC-P	Max TE _L < 1.35µs	Max TE _L < 1.35µs
T-TSC-P	Max TE _L < 1.35µs	N/A

The level of noise that a PTS device must tolerate on its PTP input is max|pktSelected2wayTEI according to the network limit defined in ITU-T G.8271.2 clause 7.3.2.1 at the PTP input, and wander tolerance according to clause 9.1 of [ITU-T G.8262] at the synchronous equipment clock input.

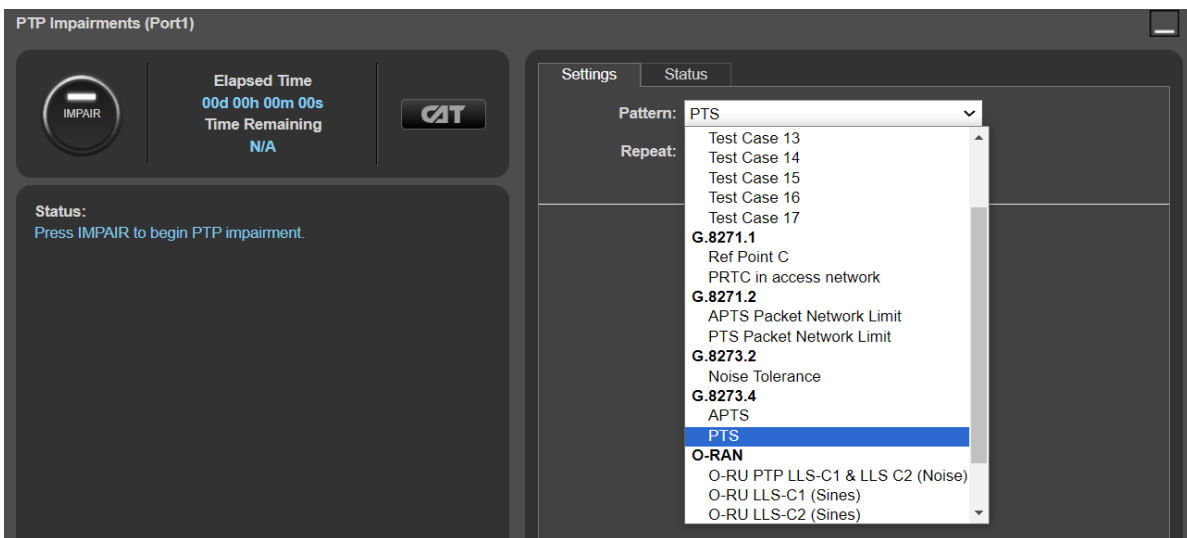
For the PTP input testing, **ITU-T G.8273.4 Appendix VI** describes the methodology to generate a PTP delay pattern for testing a PTS device. A pattern conformant to this methodology is available for selection in the Paragon-neo **PTP Impairments** app, this pattern is 32,600s (9 hours) in duration.

If the DUT has a SyncE input, then this should be tested for noise tolerance by generating wander at the SyncE input at the same time as the PTP test patterns are running.

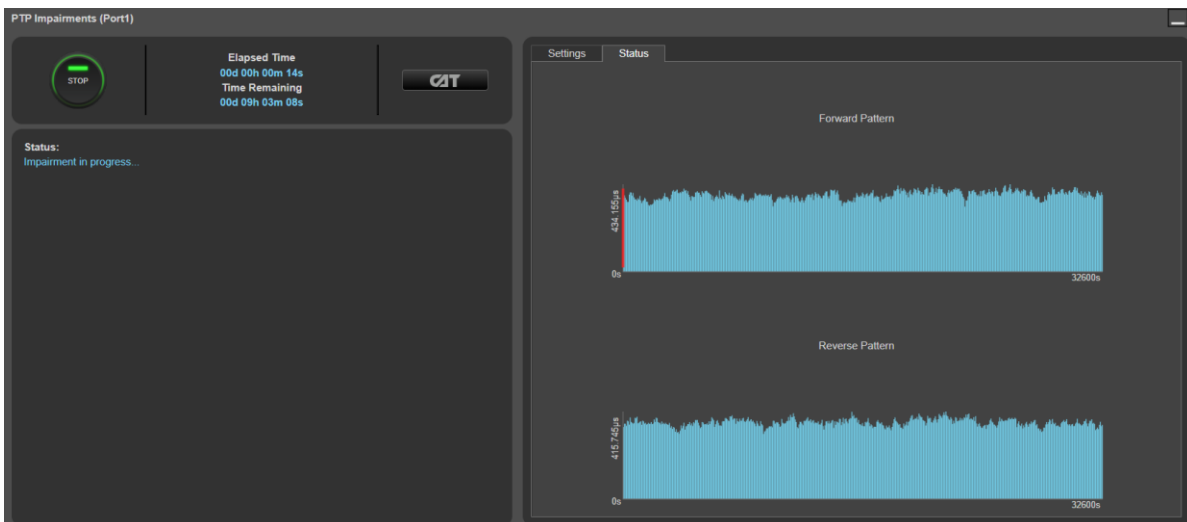


Measurement Process

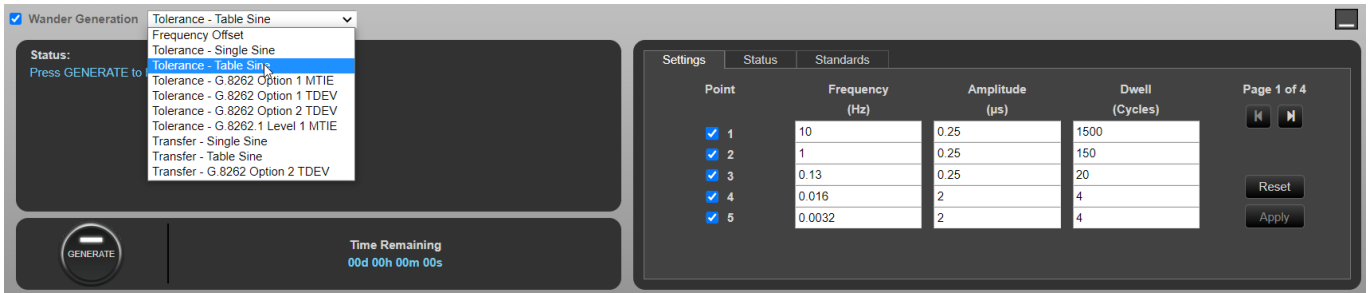
1. Confirm that preconfigured settings within PTP emulation are appropriate for the current test scenario, as described in Section 4.4.
2. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.
3. From the **PTP Emulation** app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run. From the **1pps Time Error Measurement + Time of Day** app selecting **Measure** then selecting **CAT** will launch the Calnex Analysis Tool, allowing confirmation that the device 1PPS output is stable and ready to test.
4. From the **Pattern** drop-down menu of the **PTP Impairments** app, select the **G.8273.4 PTS** Time Error Pattern, ensure that the **Repeat** option is set to **No**. Then select **Impair**.



While running, the **Status** tab will show progress through the impairment pattern; the current position within the pattern is indicated by the red bar.

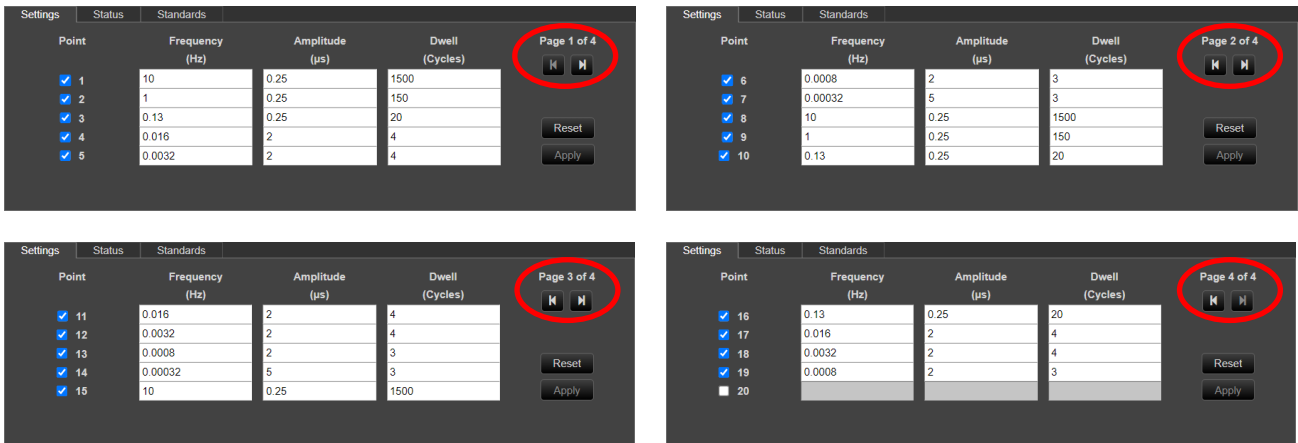


5. If SyncE wander generation is required, select **Tolerance – Table Sine** from the **SyncE Wander Generation** app.



6. Enter the following values to generate the required wander generation profile, note there are four pages, then select **Apply**. Select **Generate** to start wander generation.

Note: The settings below repeat the tones that are used for the **G.8262 Option 1** enough times such that there will be SyncE wander applied concurrently throughout the full PTP impairment pattern (approx. 9 hours). It is also possible to use the default tones and restart when complete (after approx. 4h 11m). A future Paragon-neo firmware release will add a feature to repeat the pattern.

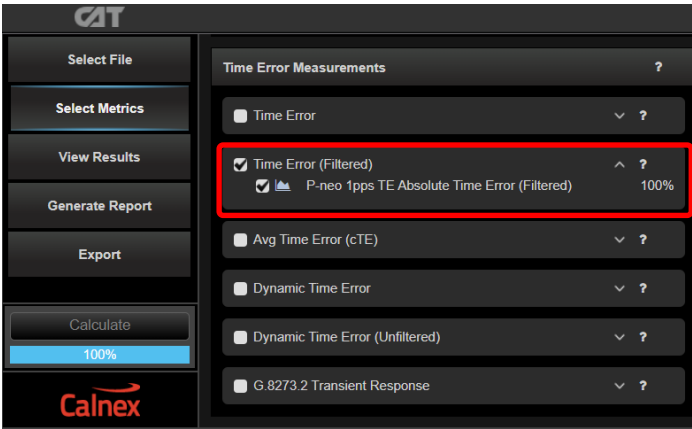


- If required, wait an appropriate amount of time for the DUT to stabilise after the impairments have been applied. There are no conformance requirements regarding the amount of time this should take, however up to 15 minutes is reasonable.
- If the DUT is a T-BC-P, in the **PTP Emulation** app, select **Measure**.
- If the DUT has a 1PPS output, in the **1pps Time Error Measurement + Time of Day** app selecting **Measure**.
- Selecting **CAT** within either the **PTP Emulation** or **1pps Time Error Measurement + Time of Day** apps will launch the Calnex Analysis Tool where the performance of the DUT outputs can be monitored.
- Monitor the DUT to confirm it has not raised alarms, switched reference, or entered holdover.
- Monitor the **Time Remaining** indicator on the **PTP Impairments** app, when the indicator stops counting down **Stop** the running measurement(s).

Results Analysis

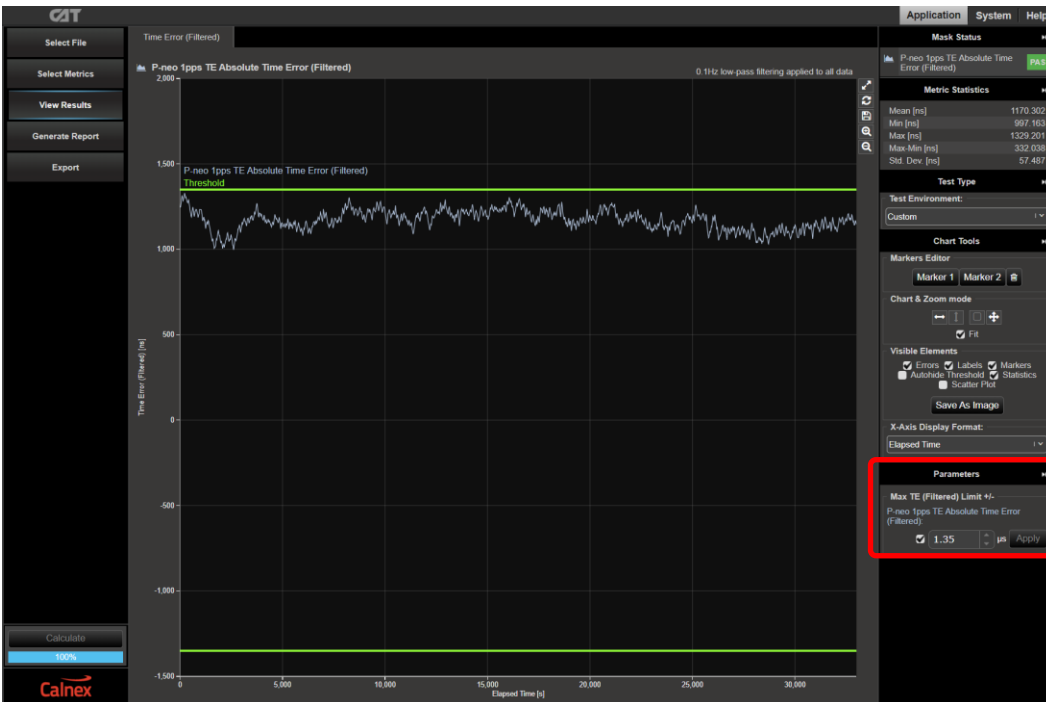
- In **CAT**, click **Select Metrics** and ensure the required **Time Error (Filtered)** plots are checked for PTP and 1PPS, then press **Calculate**. The available metrics will depend on the configured measurements.

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

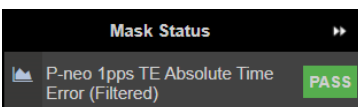


- Select **View Results** then select the **Time Error (Filtered)** tab. Set the **Max TE (Filtered) Limit** to the following as per the ITU-T G.8273.4 requirement for each available measurement and ensure that the checkbox is set to checked to apply the threshold.

DUT Class	Max TE (ns)	Max TE (Filtered) Limit (µs)
Class A or B	1350	1.35



- The T-BC-A performance meets requirements when the output is within the applied threshold. The Pass/Fail status is indicated in the **Mask Status** block in the top-right area of the CAT display.

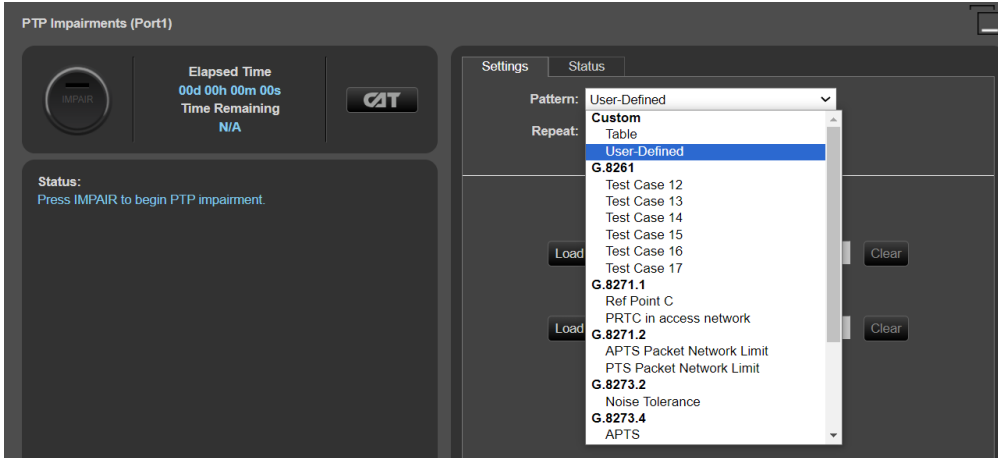


- Review the status and error logs of the DUT if they are available to confirm it has not any raised any alarms, switched reference, or entered holdover during the timeframe that it was using the PTP input.

Further Analysis (Optional)

As there will be many different deployed network topologies and traffic conditions for PTS and APTS networks, where possible it is recommended to capture real network Time Error patterns and perform the testing above using these patterns as the impairment to verify that DUT performance is as expected in real world environments. Paragon-neo is capable of replaying Time Error patterns such as those captured using **Paragon-x** or the **Calnex Sentinel** field tool.

To replay a captured file, select **User Defined** in the **PTP Impairments > Pattern** drop-down list.



Selecting **Load** will open File Explorer to allow the selection and loading of any suitable file onto Paragon-neo.

13 Time Noise Transfer for PTS devices – G.8273.4 Clause 8.3

Test Description

In the passband, the phase gain of the DUT should be smaller than 0.1 dB (1.1%).

Measurement Process

There is no bandwidth specified for these types of clocks, and only the maximum phase gain of 0.1dB is specified. This means that the clock should not amplify any noise on its inputs by more than 0.1dB.

Since there is no bandwidth specification, it is not possible to define a deterministic test for the transfer specification. Further, 0.1dB is far less than the permitted noise generation, and therefore cannot be observed in practice.

The specification should be viewed not a testable requirement but rather as an indication to the designer that amplifying the input signal is not permitted.

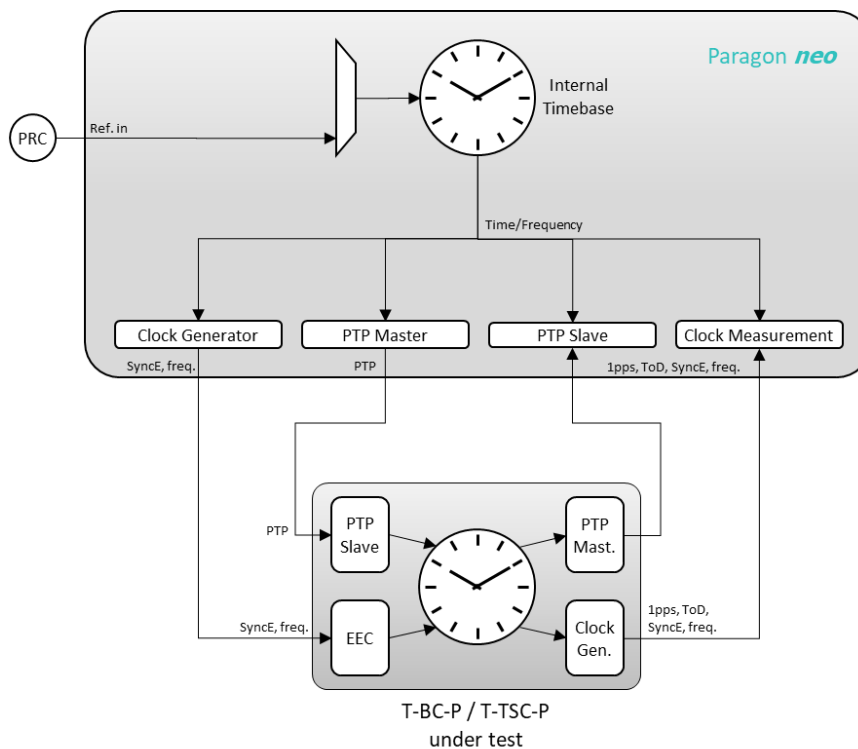
14 Transient Response and Holdover Performance for PTS devices – G.8273.4 Clause 8.5 & 8.6

Test Description

The transient response specifies the maximum size of the transient on loss and restoration of the PTP reference. The holdover performance specifies the clock drift upon loss of references. The masks cover both the transient and holdover aspects for the relevant tests.

Performance is specified for two scenarios:

1. Loss of all references to the DUT, holdover is based on the local oscillator. This scenario has an allowance for an initial transient of 22ns followed by a drift to 1.0278µs over the subsequent 1000s and a 22ns transient when exiting holdover.
2. The DUT has a frequency (e.g. SyncE) reference available. This scenario has an MTIE limit based on ITU-T G.8273.2 Clause 7.4.2.2 that specifies the requirements for phase/time performance upon and during loss of the PTP input reference.



Measurement Process

1. Confirm that preconfigured settings within the **PTP Emulation** 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. Follow the steps in the sections below that apply to the DUT.

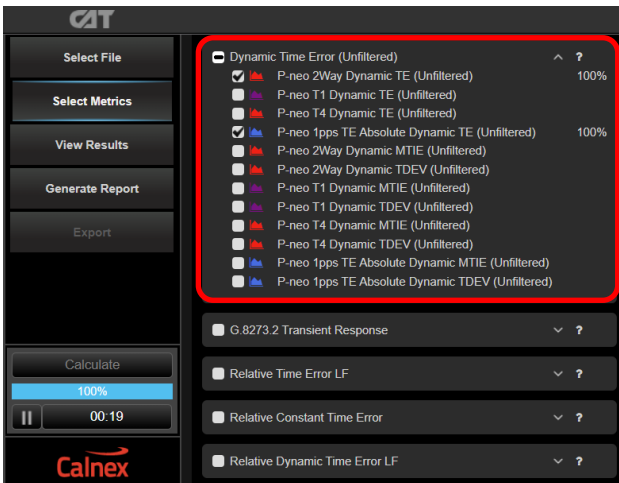
14.1 Phase Transient and Holdover based on a local oscillator (Clause 8.5.1 & 8.6.1)

Note: The G.8273.4 clause 8.6.1 defines the permissible phase error in terms of Delta T (TIE), this definition is described as accounting for the 22ns transients at entry and exit of holdover, this definition is available as a **CAT** mask. Only 1PPS and PTP signal types have transient performance requirements.

1. From the PTP Emulation app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run.
2. Select **Measure** on the relevant measurements (i.e. PTP, 1PPS) then select **CAT** to launch the Calnex Analysis Tool, verifying that the device timing output is stable and ready to test – this may take up to one hour, dependent on the DUT, once the device is stable **Stop** all measurements.
3. Select **Measure** on the relevant measurements then remove all reference sources from the DUT by, e.g. removing cables.
4. Allow the measurement to continue for 1000s then restore the PTP reference source only. Wait for the DUT to lock to the PTP input, then **Stop** the measurement.

Results Analysis

1. Select **CAT** to launch the Calnex Analysis Tool. In **CAT**, use the **Select Metrics** button. Ensure **Time Error** and **Dynamic Time Error (Unfiltered)** have been enabled. It is recommended to only select the following **Dynamic Time Error (Unfiltered)** metrics to simplify observing the results:



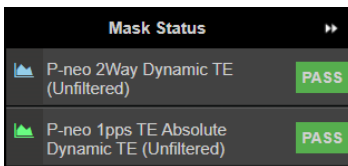
2. In **CAT** select the **Dynamic Time Error (Unfiltered)** tab and apply the **G.8273.4 PTS Holdover (Oscillator) Const. Temp.** mask to all measurements.

- If there is a noticeable transient in the plot when the reference to the DUT was removed, then this should be aligned with the start of the of the mask. If there is no visible transient then the start of the mask should be aligned with the point that the PTP reference to the DUT was removed.

To adjust the start point of the mask, select the **Time Error** tab and adjust the Data Analysis Range values to align the start of the mask with the start of that event. This can be performed by manually entering the values, or by click and dragging the blue start of plot marker. The mask in the dTE (Unfiltered) tab will auto-adjust to maintain its symmetry with the first measurement value in the selected range, if **Coupled Ranges** is checked (the default setting) then the same analysis range will be applied to all measurements.

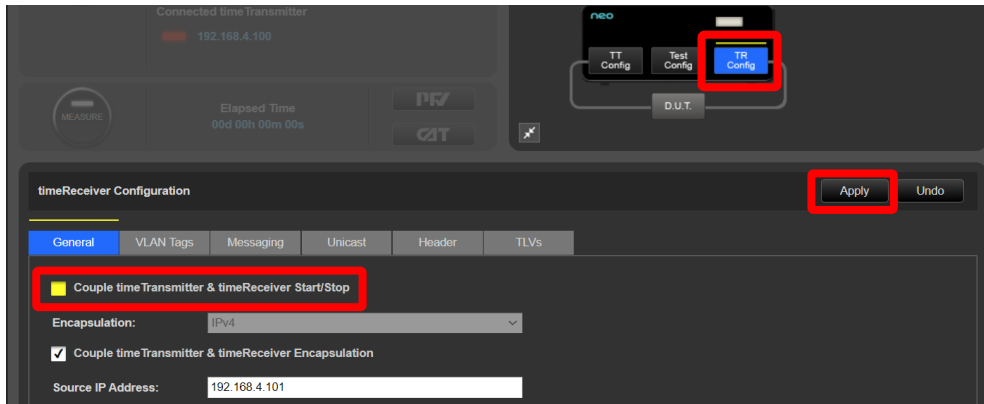


- Select the **Dynamic Time Error (Unfiltered)** tab. The device performance meets requirements when the output is within the applied mask. The Pass/Fail status is indicated in the **Mask Status** block in the top-right area of the CAT display:

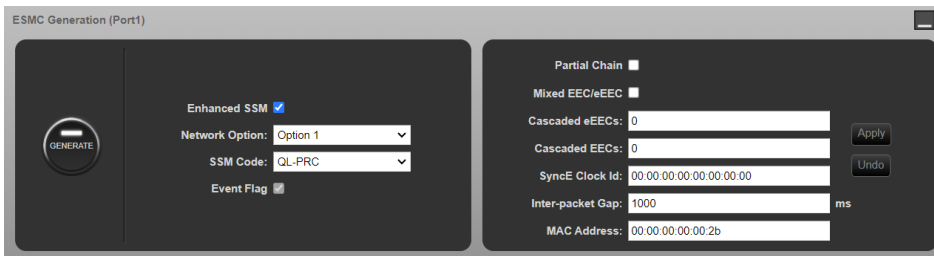


14.2 Phase Transient and Holdover based on physical layer frequency assistance (Clause 8.5.1 & 8.6.2)

Note: If SyncE is required, both SyncE and PTP are presented to the DUT on the same cable from Paragon-neo. To stop the PTP input to the DUT while measuring the PTP output, it is required to decouple the timeTransmitter and timeReceiver start/stop so that only the timeTransmitter providing the reference to the DUT is stopped. This is done by unchecking the *Couple timeTransmitter and timeReceiver Start/Stop* checkbox in the **TR Config - General** Tab, then pressing **Apply**.



1. From the **PTP Emulation** app, press **Generate**, or if decoupled, **Generate TT** and **Generate TR** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run.
2. If using SyncE as the DUT frequency reference, from the **ESMC Generation (Port 1)** app, configure the options as appropriate to enable the DUT to use the input as a frequency reference, then press **Generate**.



3. Select **Measure** on the relevant measurements (i.e. PTP, 1PPS) then select **CAT** to launch the Calnex Analysis Tool, verifying that the device timing output is stable and ready to test – this may take up to one hour, dependent on the DUT, once the device is stable **Stop** all measurements.

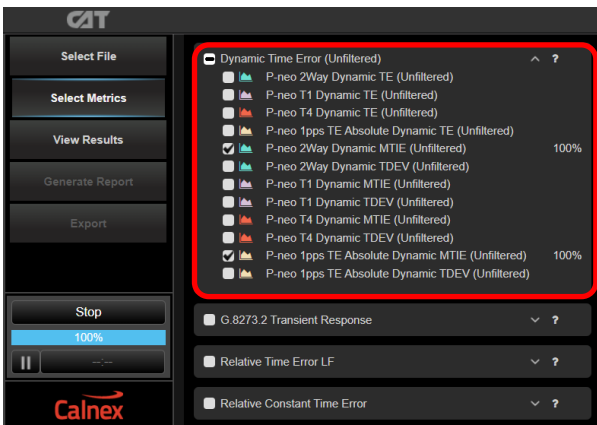
- Select **Measure** for the signal(s) that are being measured, then invalidate only the PTP input on the DUT by, e.g. removing the cable or, if the SyncE reference is on the same cable, by pressing **Stop TT**:



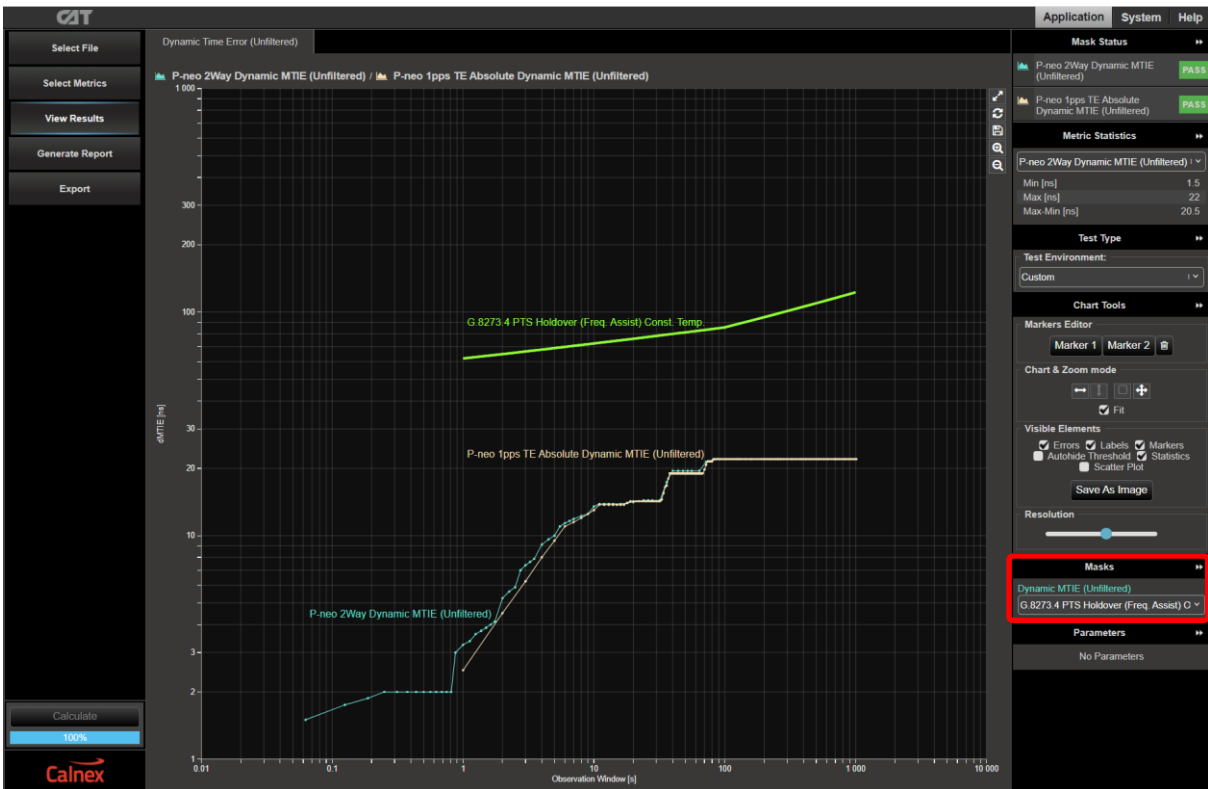
- Confirm the frequency input is still selected by the DUT. Allow the measurement to continue for 1000s then restore the PTP reference source by reconnecting the cable or by pressing **Generate TT** to restore the PTP input to the DUT.
- Wait for the DUT to lock to the PTP reference source then **Stop** the measurement.

Results Analysis

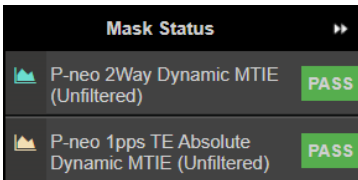
- Select **CAT** to launch the Calnex Analysis Tool. In **CAT**, use the **Select Metrics** button. Ensure **Time Error** and **Dynamic Time Error (Unfiltered)** have been enabled. It is recommended to only select the following **Dynamic Time Error (Unfiltered)** metrics to simplify observing the results:



- In **CAT** select the **Dynamic Time Error (Unfiltered)** tab and apply the **G.8273.4 PTS Holdover (Freq. Assist) Const. Temp.** mask.



- Select the **Dynamic Time Error (Unfiltered)** tab. The device 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:





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