TEST GUIDE

CX3013 v5.0

G.8273.4 Conformance Test

Testing Boundary and S-clock 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 and T-TSC compliance as per G.8273.4 and provides procedures to measure noise generation, tolerance and transfer, transient response, and holdover performance.

Contents

1. Hardware and Software Required

Paragon-neo

Opt. NEO-1G-10G	1/10GbE interface support (if the Device-Under-Test (DUT) has 1G and/or 10G interfaces)
Opt. NEO-25G	25GbE interface support (if the DUT has 25G interfaces)
Opt. NEO-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.8275.2	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-Background-Traffic	Background Traffic Generation (to test using ITU-T G.8273 methodologies)

Software version: 09.00.XX and 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 S-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
- Calnex Application Note: Cabling Considerations (CX5009)
- Calnex Technical Guide: Partial Timing Support (PTS): Testing G.8273.4 Clocks (CX6007)

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:

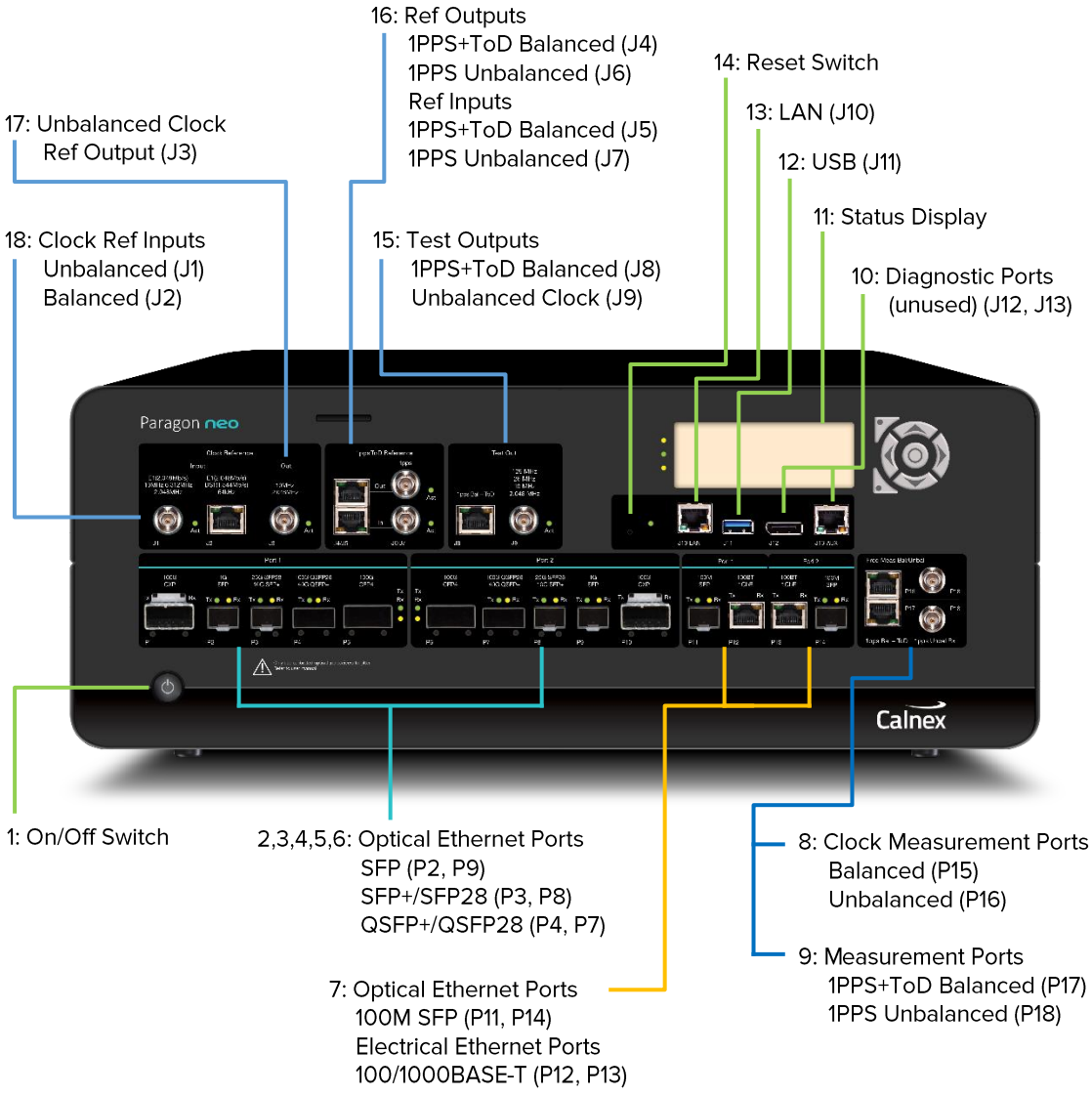
- 100GbE (QSFP28)
- 50GbE (QSFP28)
- 40GbE (QSFP+)
- 25GbE (SFP28)
- 10GbE (SFP+)
- 1GbE (SFP)

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:

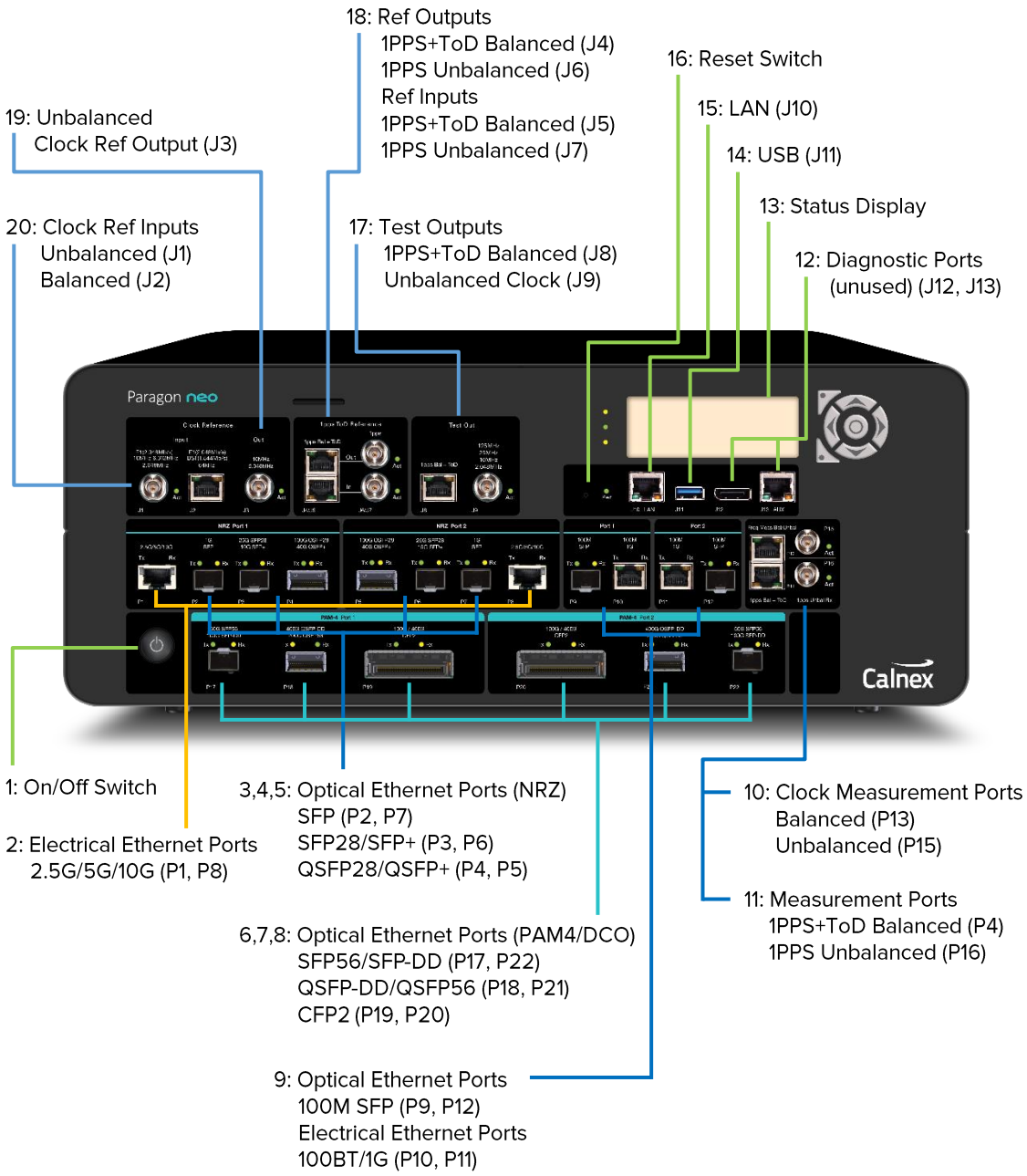
- 400GbE (QSFP-DD)
- 50GbE (SFP56)

Reference Clock Inputs:

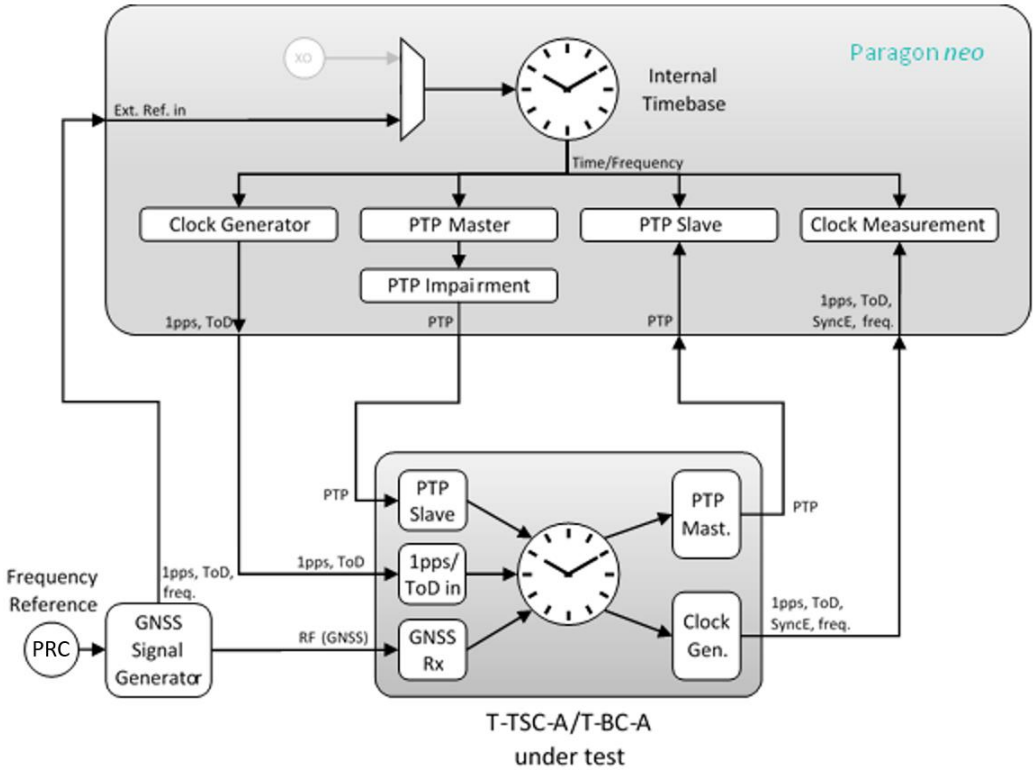
- 2.048/10MHz (Recommended)

1PPS Measurement Inputs:

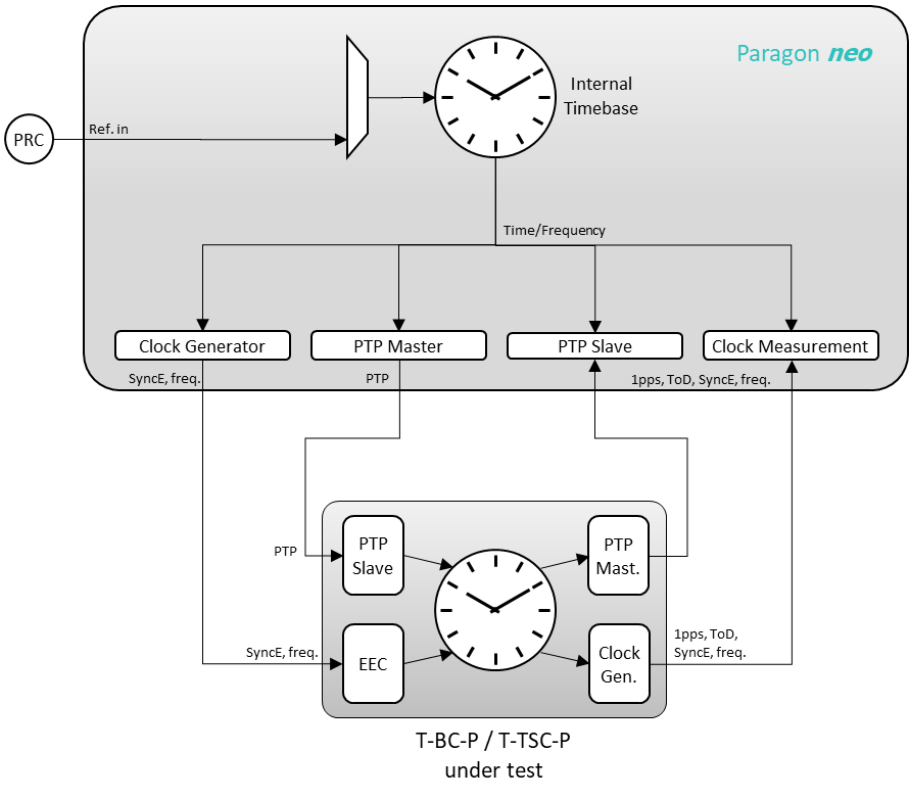
- 1PPS Balanced (RJ48)
- 1PPS Unbalanced (BNC)



Assisted Partial Timing support test configuration:



Partial Timing support test configuration:



Connections

1. Connect Port 1 (Master side of Paragon-neo) to the DUT S-Clock side.
2. For T-BC testing, connect Port 2 (S-Clock side of Paragon-neo) to the T-BC Master 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 testing. Additional notes for this measurement are in the Transient and Holdover test sections.
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.

It is highly recommended to read this test guide in combination with the associated Calnex Technical Guide *CX6007: Partial Timing Support (PTS): Testing G.8273.4 Clocks*

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:

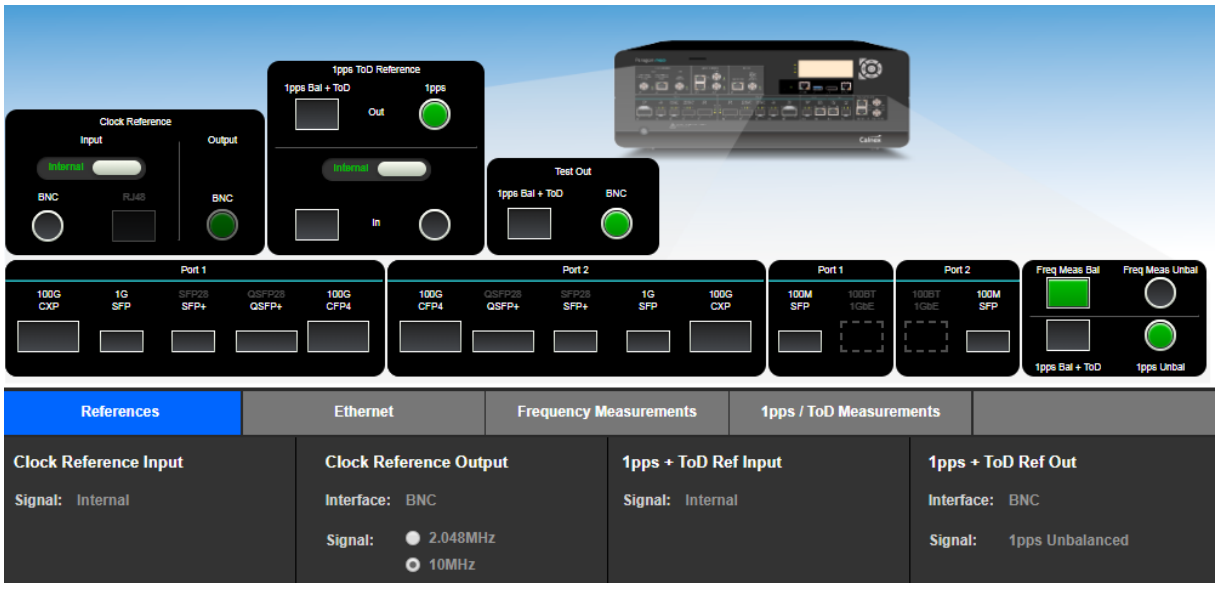
4.1 Connection to Paragon-neo
4.2 Configuration of Physical Connections
4.3 Test Configuration
4.4 Device Connection Settings
4.5 Background Traffic

4.1. Connection to Paragon-neo

1. Verify the physical connections have been completed as described in Section 2.
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.



4.3. Test Configuration

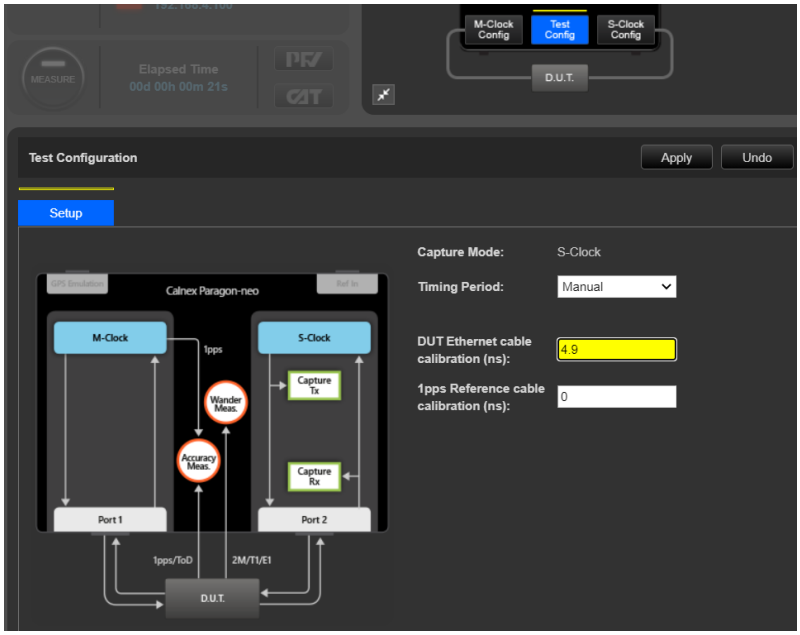
Select **Run Apps,** then, if prompted, the **PTP** preset.

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 **S-Clock** as appropriate for the DUT.

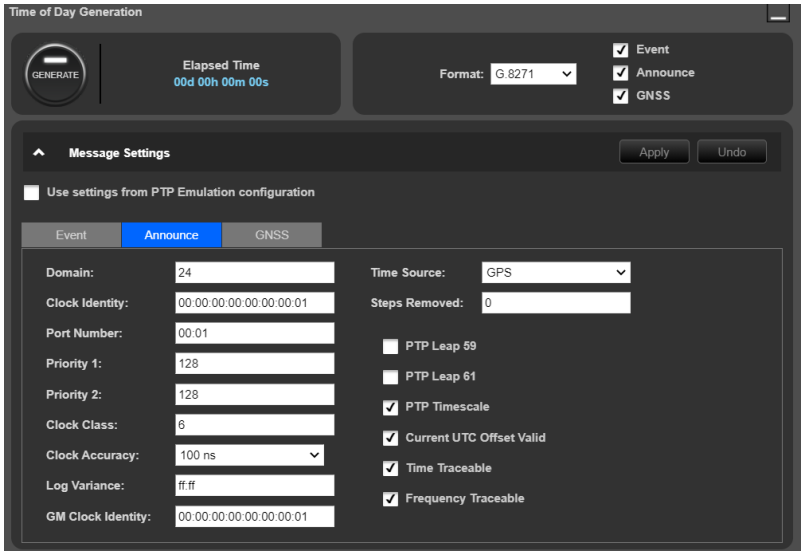
2. In the **PTP Emulation** app, choose **Test Config** and enter any relevant cable delay compensation settings in the **Test Configuration** page. Delay values are entered in ns and should be entered to at least one decimal place for best performance. A value of 4.9ns per metre of Optical Fibre is 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**.



3. 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.

4. 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.

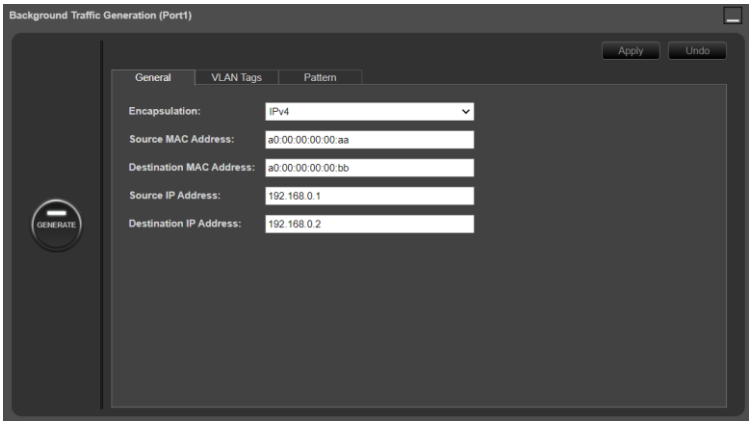


4.5. Background Traffic

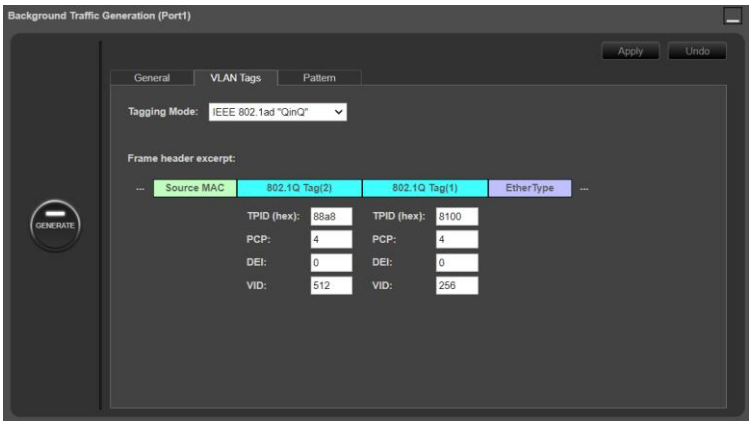
The measurement methodologies specified in ITU-T G.8273 Annex B include a requirement for traffic generation to introduce suitable loading on the ports of the DUT that carry the timing packets.

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.

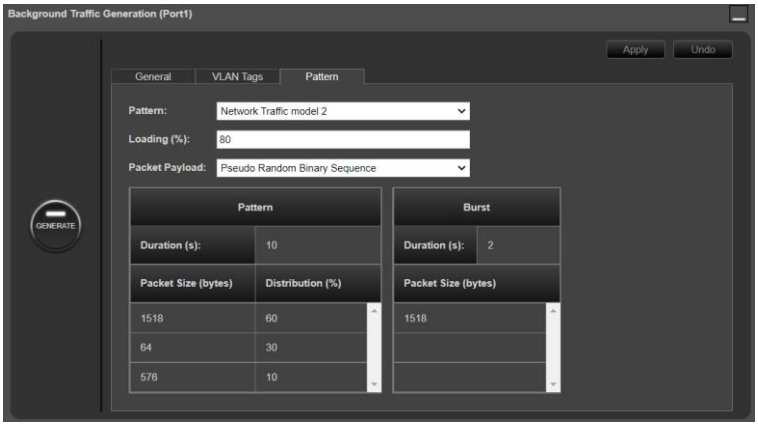
1. In the **Background Traffic Generation** app for the required Paragon-neo port, choose **General** and select the encapsulation, source and destination addresses for the generated traffic.



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.

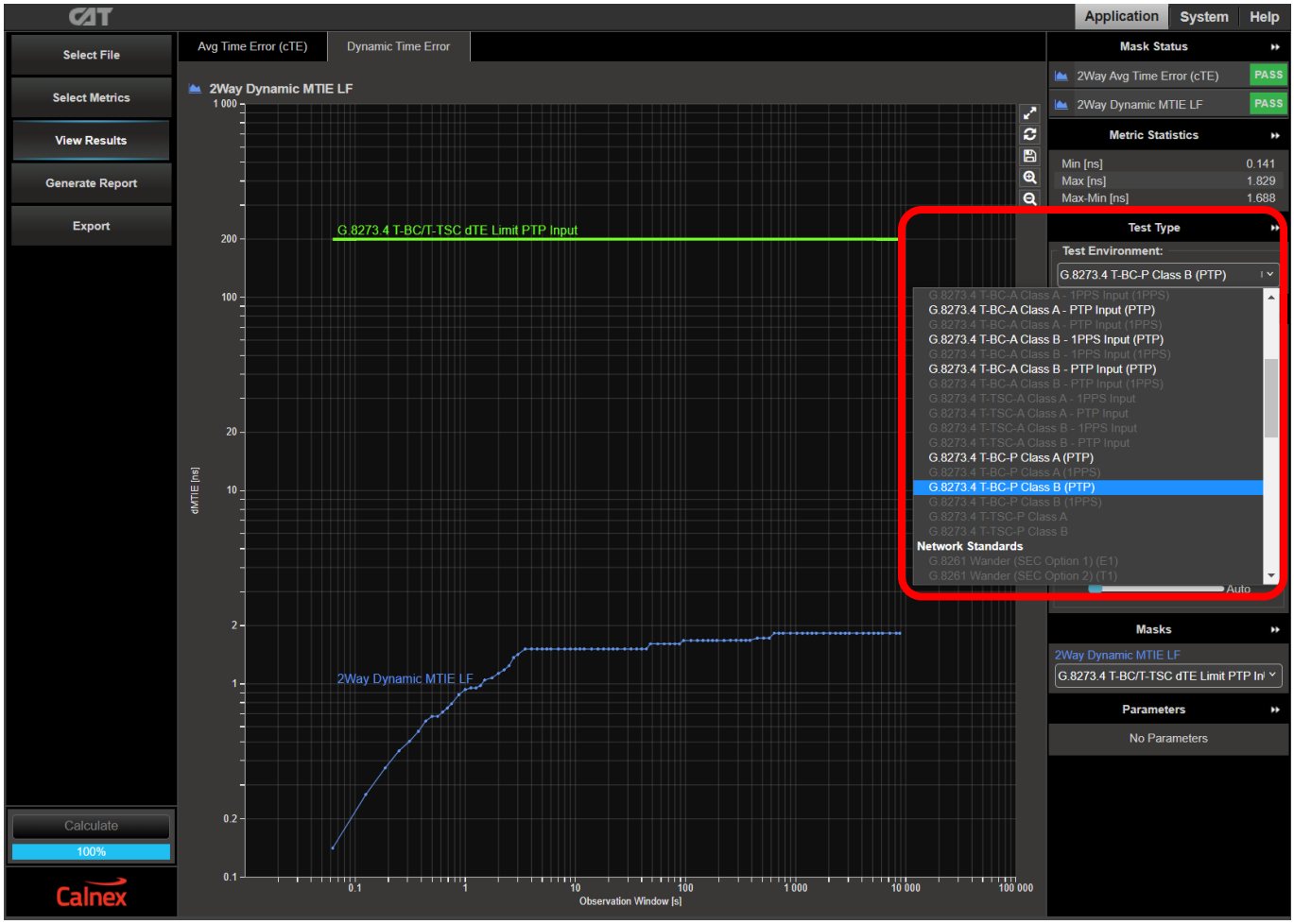
5. Analysing Results using CAT

The tests in this document detail the steps to manually set the metrics, masks and thresholds to those required to test for G.8273.4 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.

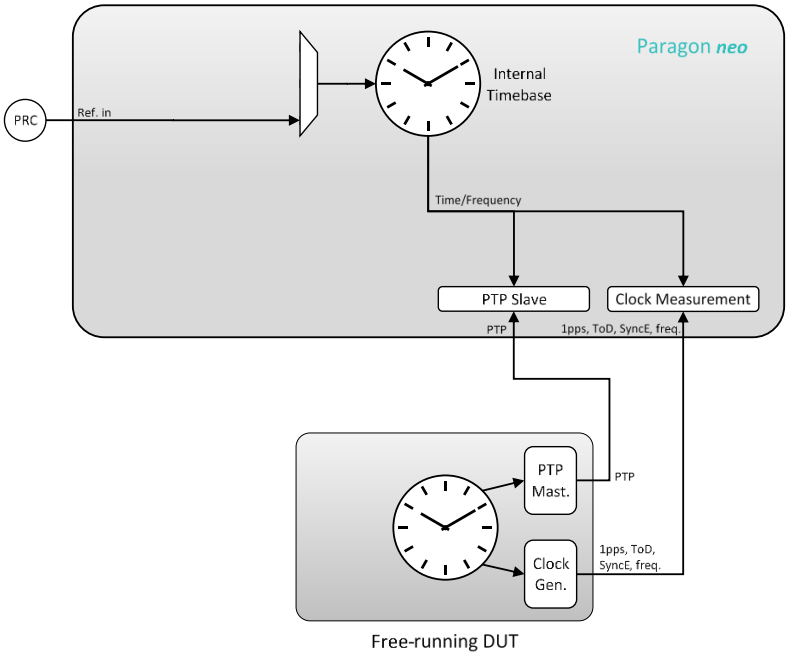
In the example below G.8273.4 T-BC-P Class B device with PTP measurements has been selected, the relevant metrics Avg Time Error (cTE) and Dynamic Time Error only are displayed, and the masks and thresholds have been set to those relevant to that device type and class.



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

Test Description

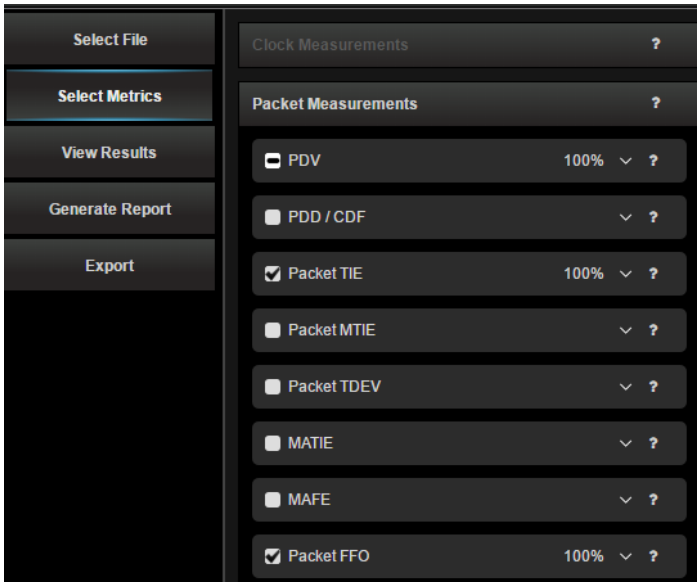
The free-run frequency accuracy for a T-BC-A and T-TSC-A is measured after power-up of the DUT with all its input signals disconnected. The free-run frequency accuracy can be measured on the PTP output (for a T-BC-A), and on the 1pps/ToD and telecom frequency outputs. The fractional frequency offset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



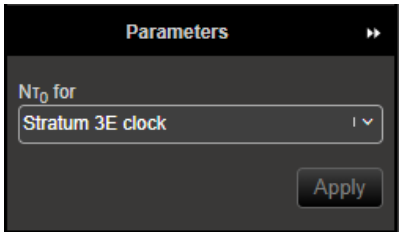
Measurement Process

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. **PTP Emulation** app should be configured in **Master Test** Mode, as no PTP input will be provided to the DUT.
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 **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 stable, **Stop** then **Start** the measurement again.
5. If measuring 1pps and/or frequency, select **Measure** in the appropriate app(s) to start the measurement.

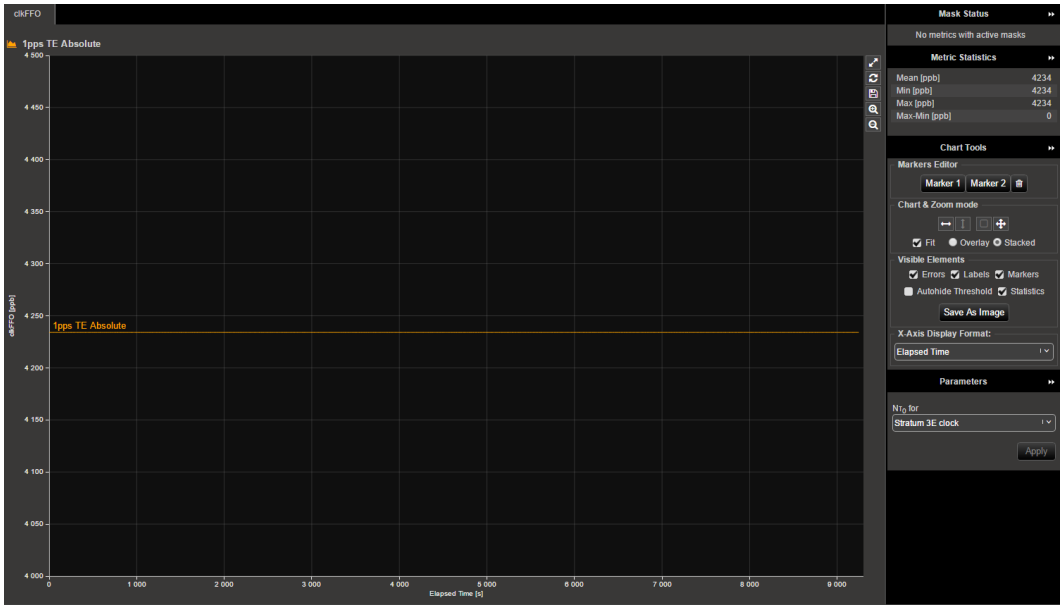
6. In **CAT**, use the **Select Metrics** button to ensure **Packet FFO** has been enabled. If measuring 1pps and/or Frequency, ensure **clkFFO** has been selected for these measurements and test in the same manner shown below. Deselecting all **Time Error Measurements** metrics is recommended to simplify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



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



8. Let the measurement run for a duration of at least 10 000s, then ensure the **Max [ppb]** value as displayed in the top right of the packet FFO graph does not exceed 4600 (i.e. 4.6ppm).
9. Note that for clkFFO measurements the value will not be displayed on the graph; the maximum should be read from the Metric Statistics panel to ensure a maximum of below 4600ppb.

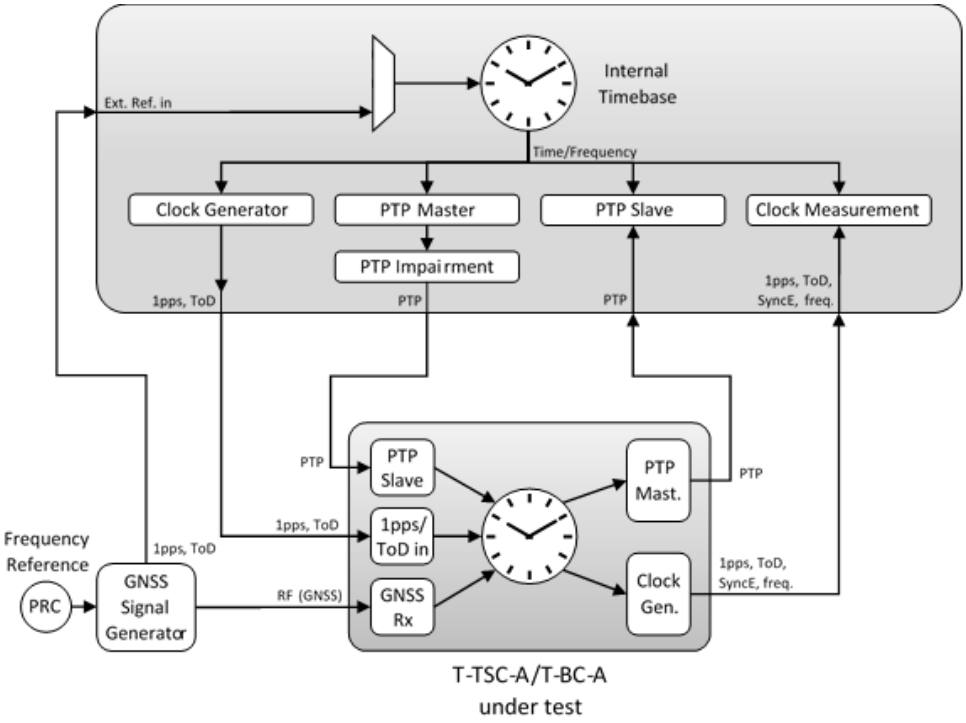


7. Noise Generation for APTS devices – G.8273.4 Clause 7.2

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.

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.



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 main reference to the DUT (based on reference options configurable on the DUT). All defined test limits are outlined in the table below. The performance requirements are currently based on having a single-time input and not multiple concurrent inputs.**

   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.

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 10).

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.

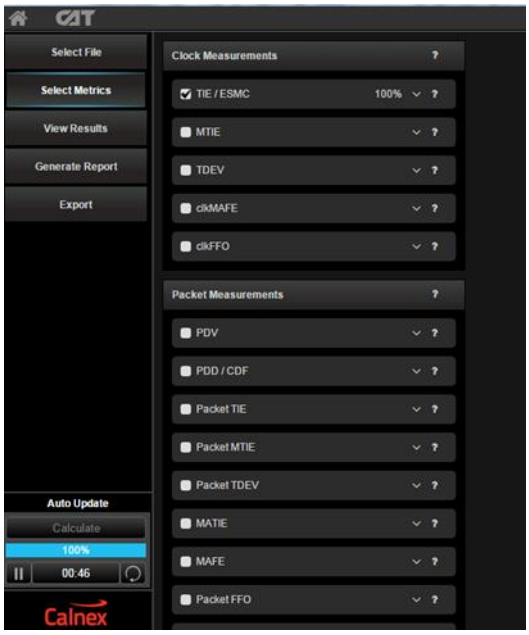
4. From the **PTP Emulation** app**,** press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run. Selecting **Measure,** then Selecting **CAT** will launch the Calnex Analysis Tool, allowing confirmation that the device timing 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.

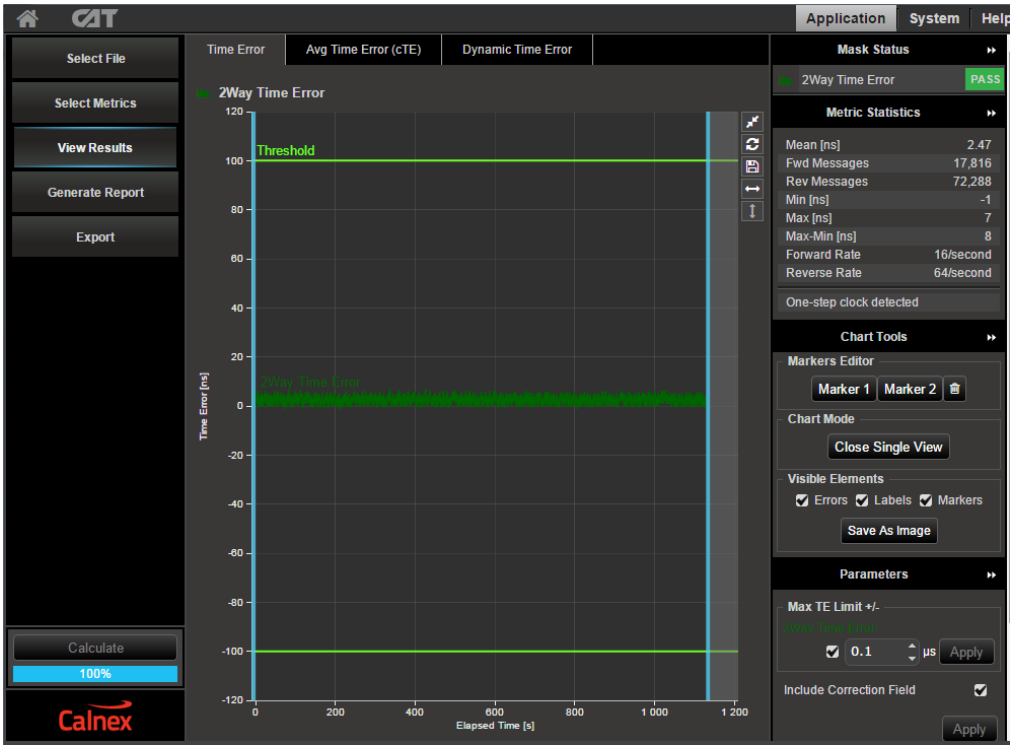
For PTP and 1pps based data these will include the metrics **Time Error, Avg. Time Error (cTE)** and **Dynamic Time Error**.

Note: When viewing **the Select Metrics** screen, the complete set of metrics can be viewed by clicking on the + symbol against each metric to expand the appropriate list in the Measurement Analysis block. **Ensure that the correct measurement data has been selected for your DUT type: PTP, 1pps or both.**



Individual graphs can be displayed by clicking on the icon circled in the display below.

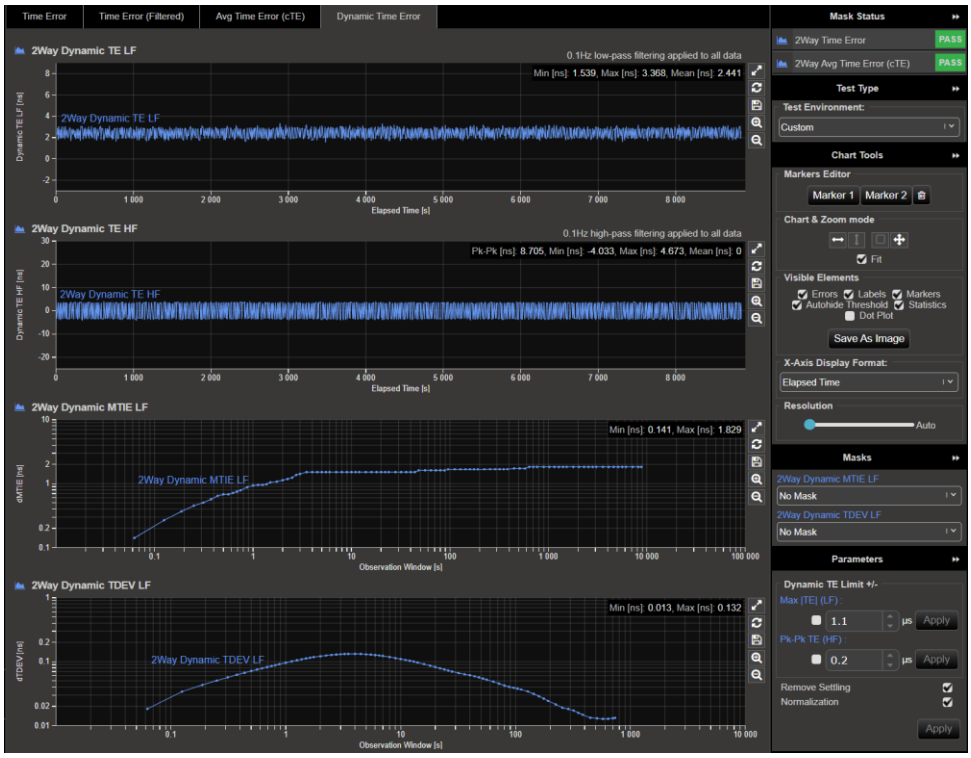
This will display a graph in single-view mode and may show more detailed metrics data:



To return to the multi-graph display click on the same icon in the single graph display.

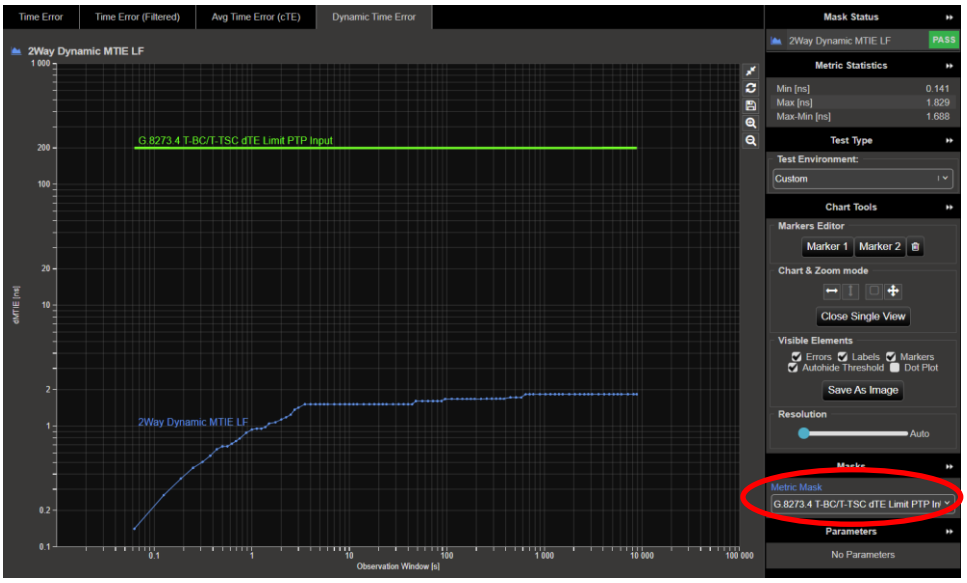
Time Error Results (Dynamic Time Error, low-pass filtered)

1. Select the **Dynamic Time Error** tab to display the **filtered** Time Error results. This will display the Dynamic Time Error results as Low Frequency measurements and High Frequency measurements. **The Dynamic Time Error tab shows the dTE$_L$ metric and is the measurement of interest for standards conformance.** As per the requirements of G8273.4, these results are filtered using a first-order low-pass measurement filter with a bandwidth of 0.1Hz.



2. Currently CAT does not report the peak-to-peak calculation directly, it is presented via the MTIE metric. The largest MTIE window calculates the maximum time error between any two samples in the whole capture, therefore the largest value in the MTIE plot is the peak-to-peak value and the applied MTIE mask tests for pass/fail.

   Apply the appropriate MTIE mask for the input type to the DUT:



3. Check for PASS/FAIL against the configured limits. If the results pass then the status in the **Mask Status** Block will indicate PASS. Mask failure will be indicated by FAIL.

Time Error Results (Constant Time Error) – for APTS devices with 1pps input

1. Select the Avg Time Error (cTE) metric tab to show the 2Way Avg Time Error (cTE) graph.

2. Set the **cTE Limit** to 50ns (0.05µs) for Class A devices, or 20ns (0.02 µs) for Class B devices.

DUT Class	Time Input	cTE
Class A	1pps	±50ns
Class B	1pps	±20ns

3. Check for PASS/FAIL against the configured limits. If the results pass, the status in the **Mask Status** Block will indicate PASS. Mask failure will be indicated by FAIL.

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**.

8. 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.

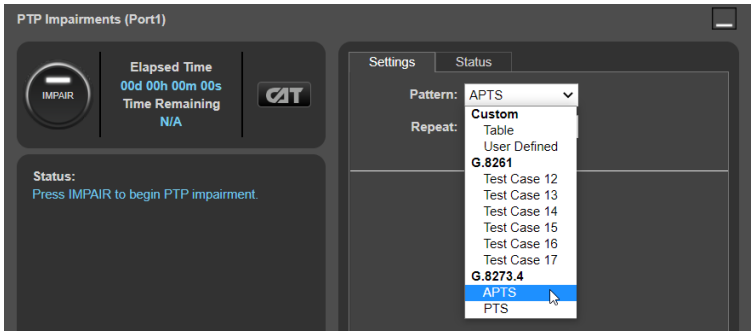
The noise tolerance of an equipment clock indicates the minimum time error level at the input of the clock that should be accommodated while: **not causing any alarms; not causing the clock to switch reference; not causing the clock to go into holdover, and, for a T-TSC-A, maintaining the maximum absolute time error (max|TEL|) at its 1pps output below the level indicated in clause 7.4.1 of [ITU-T G.8271.2]. i.e. Max|TEL| < 1.35µs**

Appropriate noise types for a GNSS input are not defined and are out of the scope of this document. However, if a configurable GNSS signal generator is available, it is recommended to consider likely GNSS noise scenarios during device deployment and confirm DUT performance under these conditions using the measurement methodology as for PTP Time Noise Tolerance described in this section.

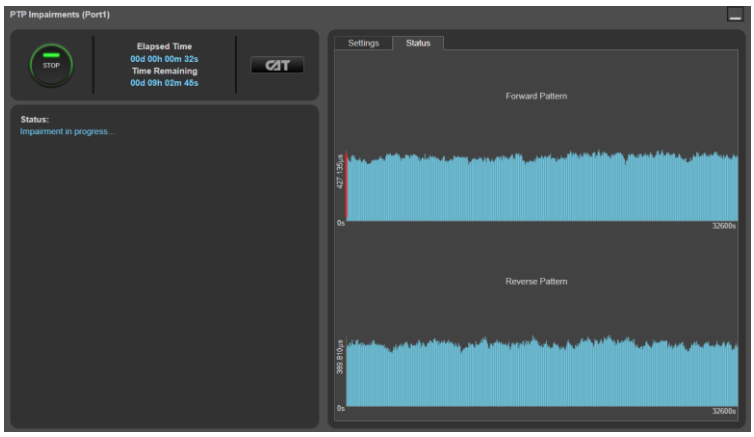
An equipment clock must be capable of tolerating noise matching peak-to-peak pktSelected2wayTE according to [ITU-T G.8271.2] network limit, clause 7.3.1.1 at the PTP input. **ITU-T G.8273.4 Appendix VI** describes the methodology to generate a PTP delay pattern for testing an APTS device. A pattern conformant to this methodology is available for selection in the Paragon-neo **PTP Impairments** app, this pattern is 32,600 seconds (9 hours) in duration and has a cTE of -12µs.

Measurement Process: PTP Noise Tolerance

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. 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.
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.



6. From the **1pps Time Error Measurement + Time of Day** app selecting **Measure** then selecting **CAT** will launch the Calnex Analysis Tool.

7. 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.

8. 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,** however, these results are expected and should be ignored.

9. After the PTP input has been selected, monitor the DUT to confirm it does not raise any additional alarms, switch reference, or enter holdover.

10. Launch **CAT** at any time to monitor the DUT 1pps output timing performance.

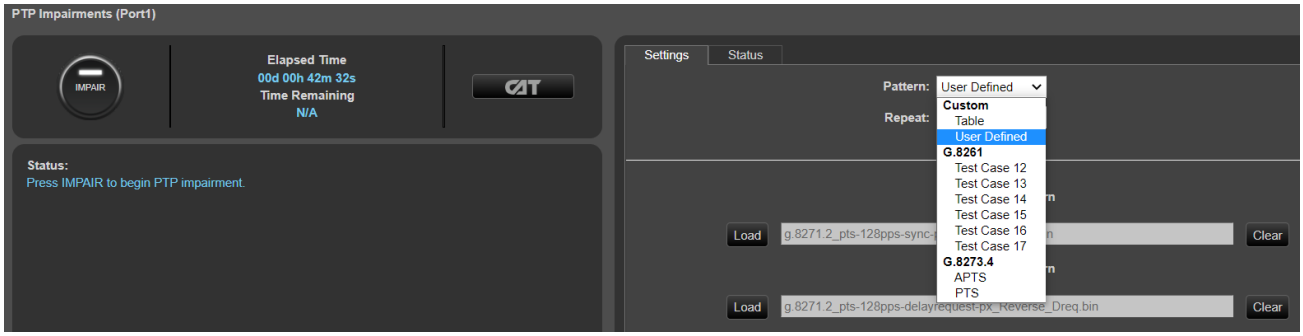
11. Once the impairment pattern has completed, **Pass/Fail for the Max $|TE_L|$ metric** for the 1PPS output can be determined by enabling the **Time Error (Filtered)** metric. Then, apply the limit of **1.35µs** in the **Parameters** section in the bottom-right of the **CAT**.

12. 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.

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

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.

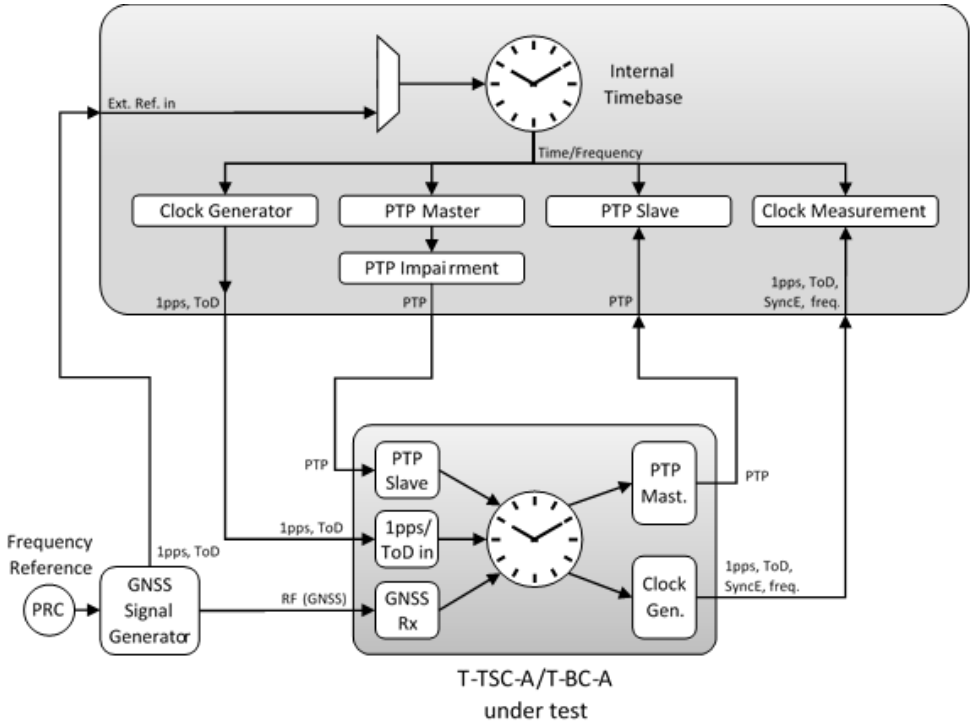
This specification should be viewed not as a testable requirement but rather as an indication to the designer that amplifying noise present on the input signal is not permitted.

10. 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: one with loss of all references with 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; and one where there is a PTP reference available, with 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

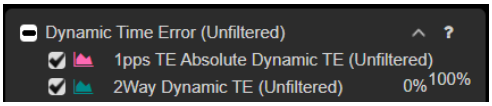
Confirm that preconfigured settings within **PTP emulation** and, if required, **Time of Day Generation** are appropriate for the current test scenario, as described in Section 3.4.

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.

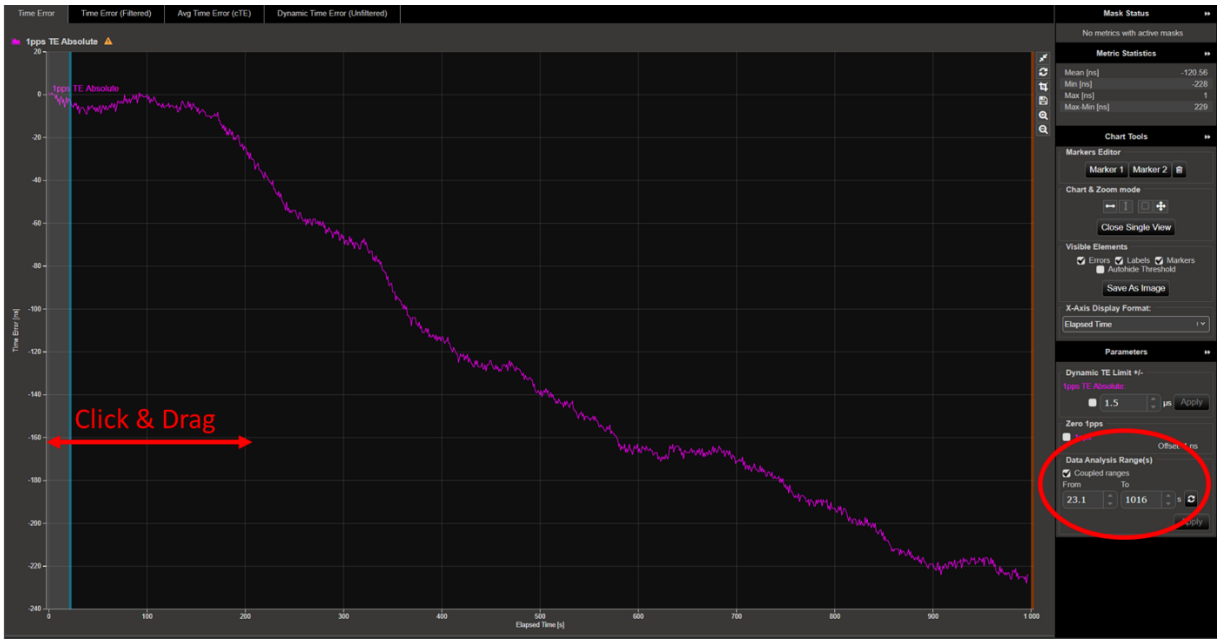
1. Ensure all required references are connected to the DUT, if required start the external GNSS RF or, if using the Paragon-neo 1pps/ToD reference, select **Generate** on the Time of Day Generation App.
2. Select **Measure** on the relevant measurements (i.e. PTP, 1pps) then select **CAT** to launch 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.

5. 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:

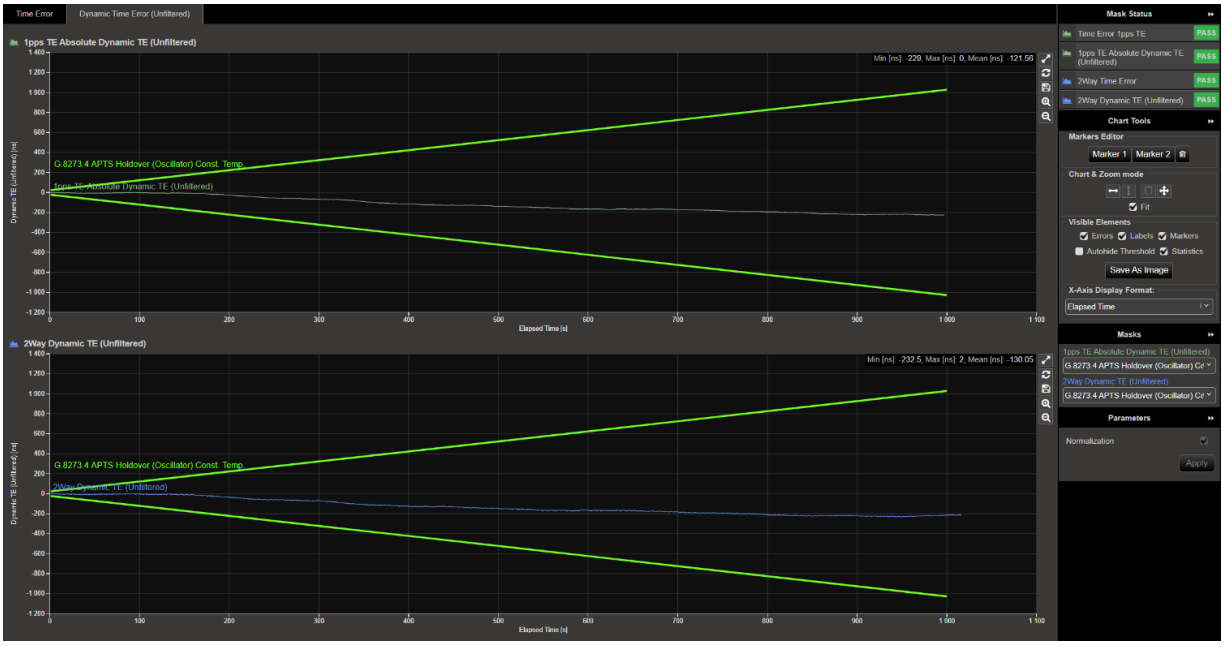


6. In **CAT** select the **Dynamic Time Error (Unfiltered)** tab and apply the **G.8273.4 APTS Holdover (Oscillator) Const. Temp.** mask.

7. If there is a noticeable transient in the plot at the point of the reference-removed event this should be aligned with the lowest point of the mask. To do this 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.



8. Select the **Dynamic Time Error (Unfiltered)** tab, check for PASS/FAIL against the configured limits. If the results pass then the status in the **Mask Status** Block will indicate PASS. Mask failure will be indicated by FAIL.



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

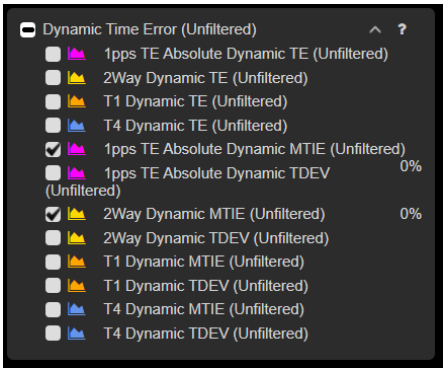
1. From the PTP Emulation app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run.

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.

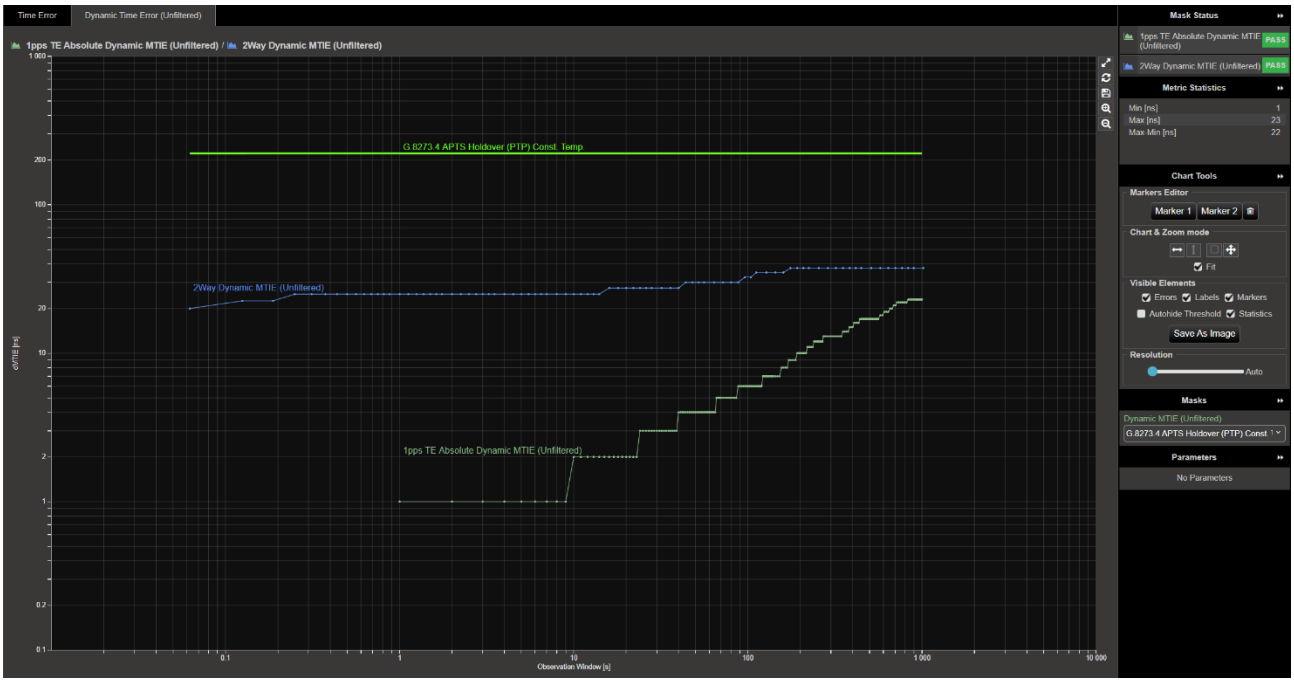
3. Select **Measure** for the signal(s) that are being measured, then remove the local time reference (e.g. GNSS or 1pps) only from the DUT by, e.g. removing the cable.

4. 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.

5. 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:



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

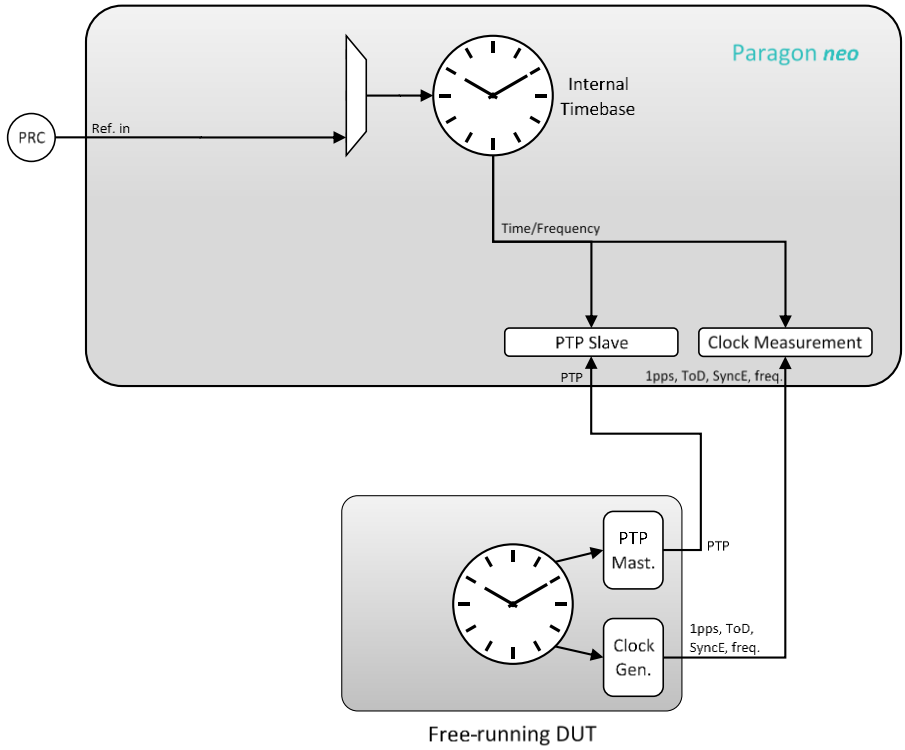


7. Check for PASS/FAIL against the configured limits. If the results pass then the status in the **Mask Status** Block will indicate PASS. Mask failure will be indicated by FAIL.

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

Test Description

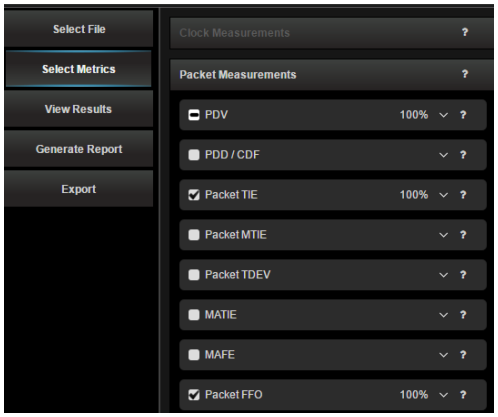
The free-run frequency accuracy for a T-BC-P and T-TSC-P is measured after power-up of the DUT with all its input signals disconnected. The free-run frequency accuracy can be measured on the PTP output (for a T-BC-P), and on the 1pps/ToD and telecom frequency outputs. The fractional frequency offset (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 **S-Clock Test** Mode, as no PTP input will be provided to the DUT.
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.
5. If measuring 1pps and/or frequency, select **Measure** in the appropriate app to start the measurement.

6. 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 and test in the same manner shown below.

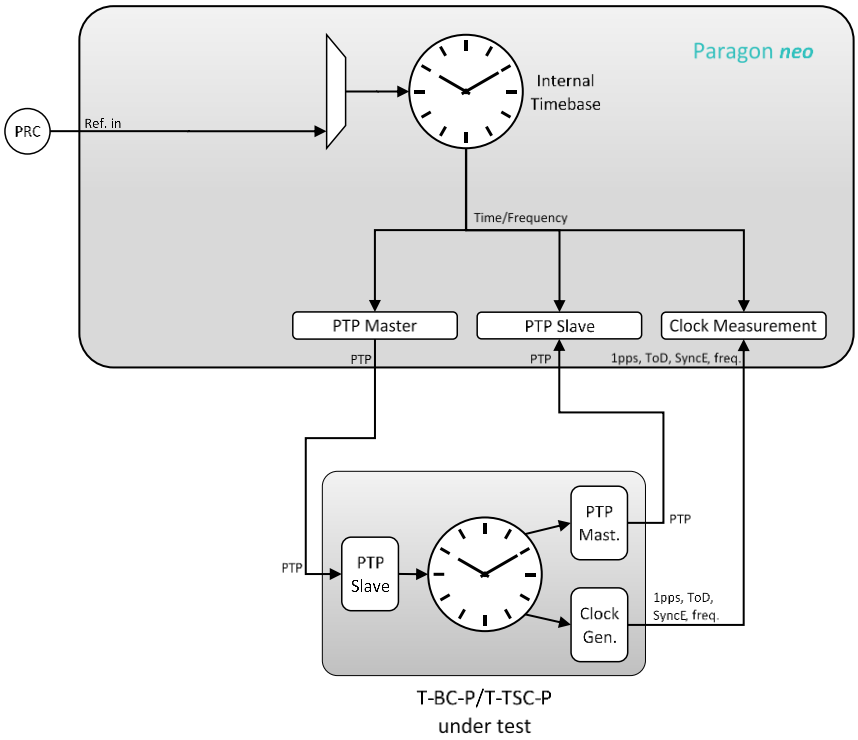


7. For the packet FFO metrics being tested, go to the appropriate tab, and ensure the **Max** as displayed in the top right of the graph does not exceed 4600ppb (4.6ppm).
8. Note that for clkFFO measurements the value will not be displayed on the graph; the maximum should be read from the plot to ensure a maximum of below 4600ppb.

12. 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).



Measurement Process

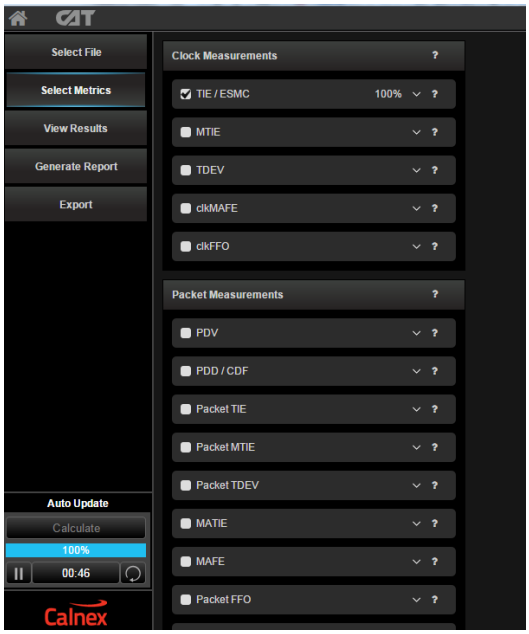
1. Confirm that preconfigured settings within PTP emulation are appropriate for the current test scenario, as described in Section 4.4.
2. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.
3. From the **PTP Emulation** 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 10000s 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.

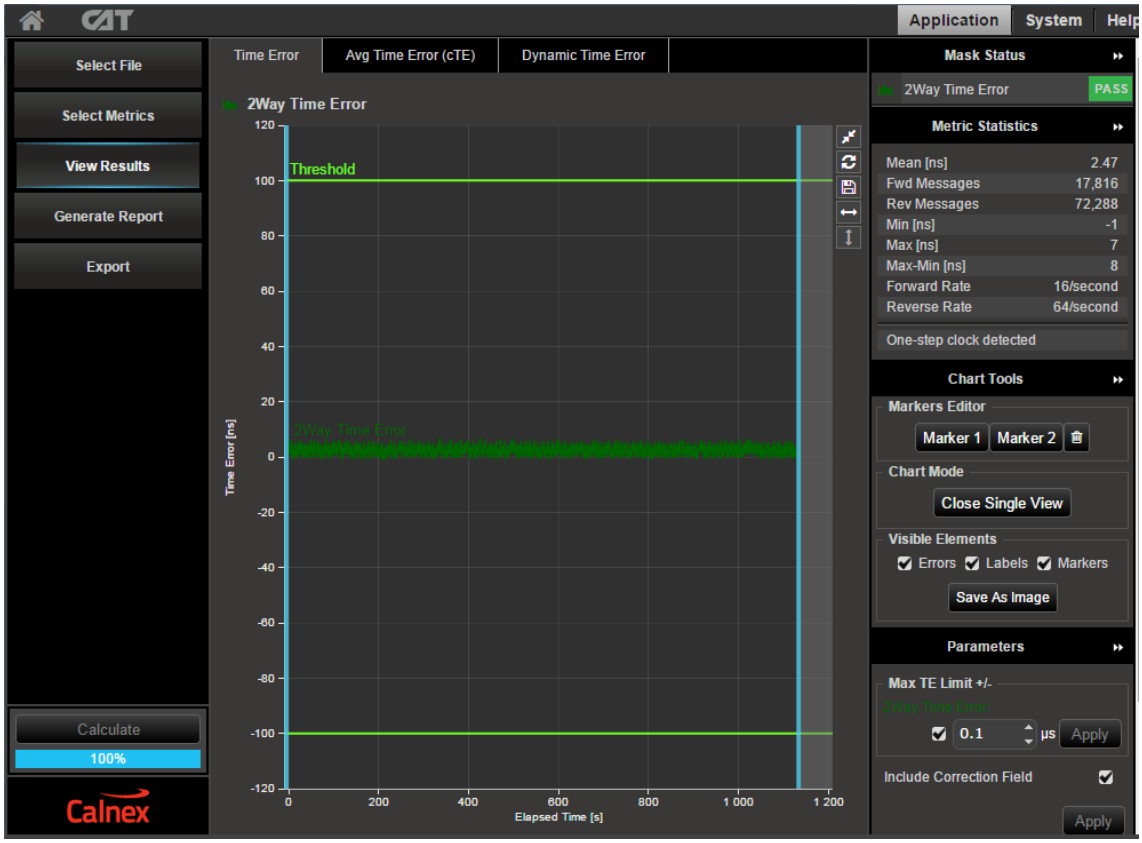
For PTP and 1pps based data these will include the metrics **Time Error, Avg. Time Error (cTE)** and **Dynamic Time Error**.

Note: When viewing **the Select Metrics** screen, the complete set of metrics can be viewed by clicking on the + symbol against each metric to expand the appropriate list in the Measurement Analysis block. **Ensure that the correct measurement data has been selected for your DUT type: PTP, 1pps or both**.



Individual graphs can be displayed by clicking on the icon circled in the display below.

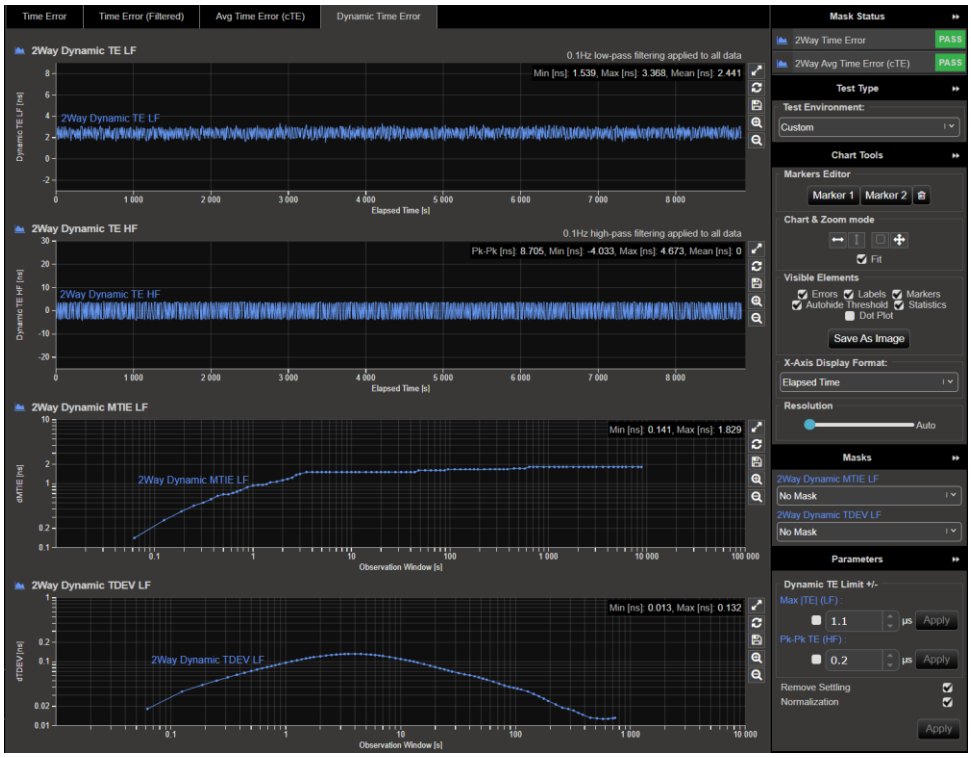
This will display a graph in single-view mode and may show more detailed metrics data:



To return to the multi graph display click on the same icon in the single graph display.

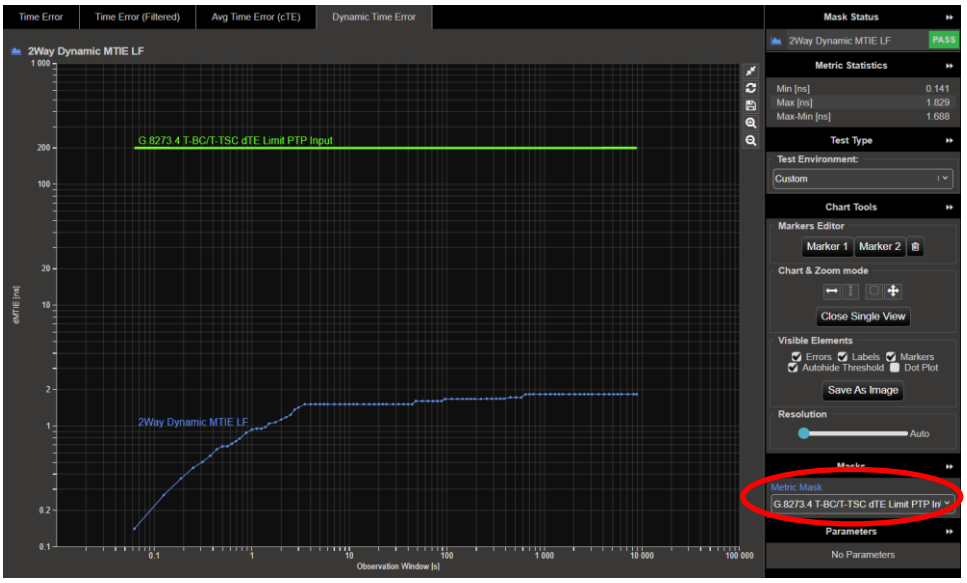
Time Error Results (Dynamic Time Error, low-pass filtered)

1. Select the **Dynamic Time Error** tab to display the **filtered** Time Error results. This will display the Dynamic Time Error results as Low Frequency measurements and High Frequency measurements. **The Dynamic Time Error tab shows the dTE_L metric and is the measurement of interest for standards conformance.** As per the requirements of G8273.4, these results are filtered using a first-order low-pass measurement filter with a bandwidth of 0.1Hz.



2. Currently CAT does not report the peak-to-peak calculation directly, it is presented via the MTIE metric. The largest MTIE window calculates the maximum time error between any two samples in the whole capture, therefore the largest value in the MTIE plot is the peak-to-peak value and the applied MTIE mask tests for pass/fail.

   Apply the appropriate MTIE mask for the input type to the DUT.



3. Check for PASS/FAIL against the configured limits. If the results pass then the status in the **Mask Status** Block will indicate PASS. Mask failure will be indicated by FAIL.

Time Error Results (Constant Time Error)

1. Select the **Avg Time Error (cTE)** metric tab to show the 2Way Avg Time Error (cTE) graph.

2. Set the **cTE Limit** to 50ns (0.05µs) for Class A devices, or 20ns (0.02 µs) for Class B devices.

3. Check for PASS/FAIL against the configured limits. If the results pass, the status in the **Mask Status** Block will indicate PASS. Mask failure will be indicated by FAIL.

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**.

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

Test Description

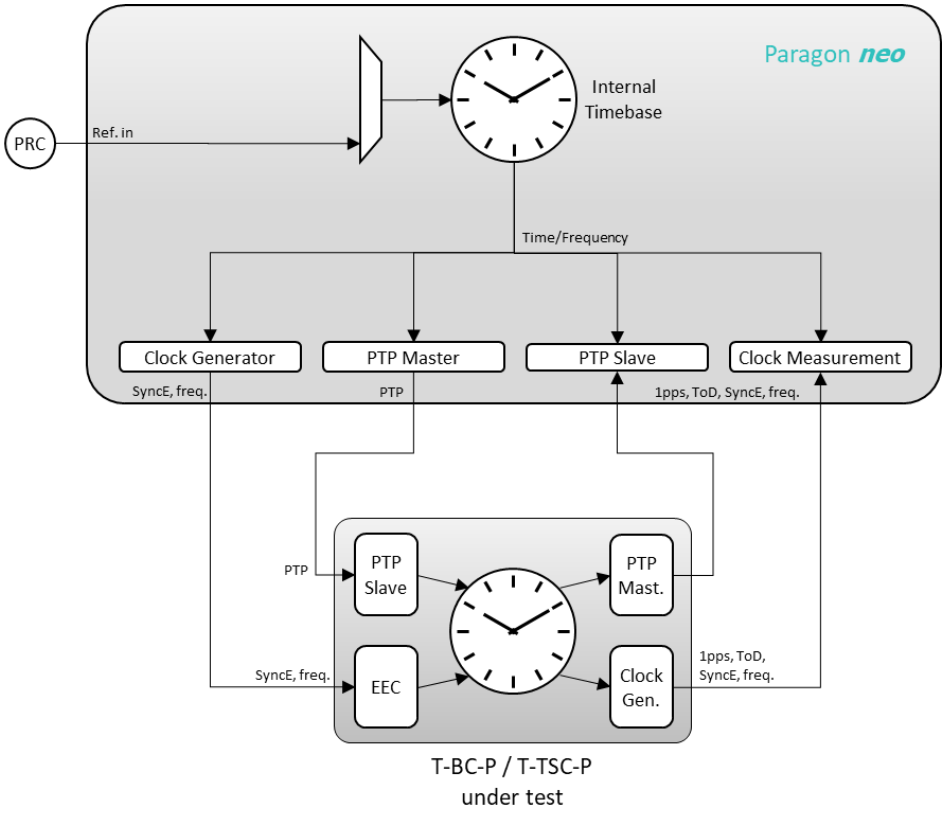
This test checks whether the equipment clock can maintain network limits at the output with maximum noise at the input.

The noise tolerance of an equipment 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, and, for a T-TSC-P, maintaining the maximum absolute time error (max|TEL|) at its 1pps output below 1350ns, the level indicated in clause 7.4.2 of [ITU-T G.8271.2]**.

An equipment clock must be capable of tolerating noise matching max|pktSelected2wayTE| according to [ITU-T G.8271.2] network limit, 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 32,600 seconds (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.



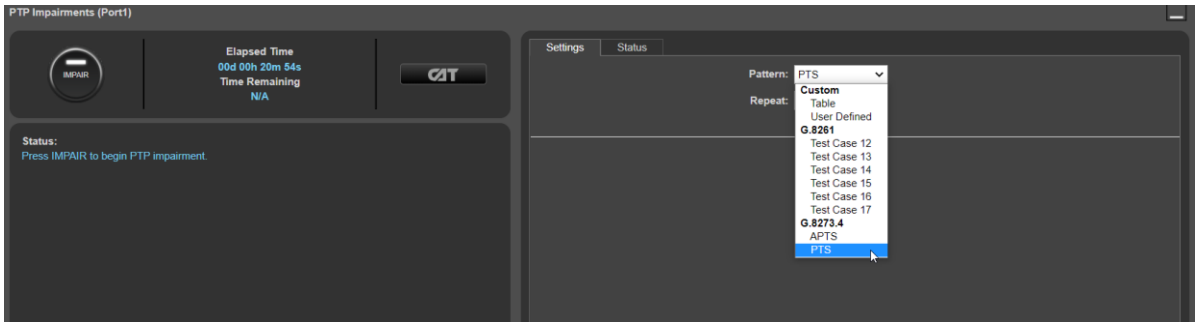
Measurement Process:

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

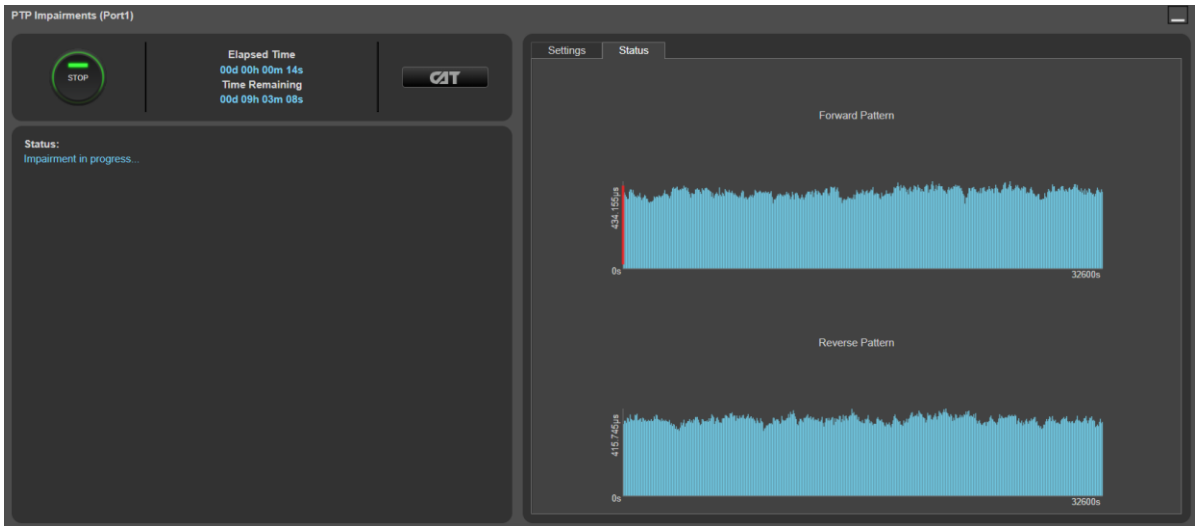
2. To test to the measurement methodology specified in ITU-T G.8273, configure the **Background Traffic** app as described in Section 4.5.

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.

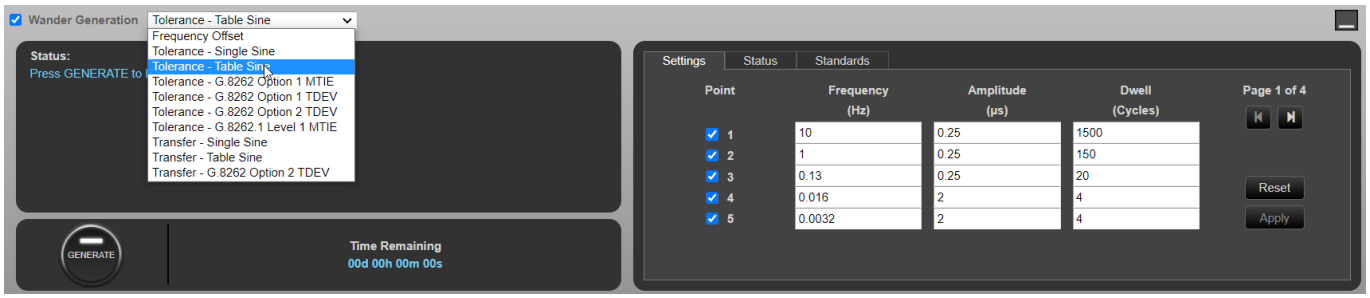
4. From the **Pattern** drop-down menu of the **PTP Impairments** app, select the G.8273.4 PTS Time Error Pattern, ensure that the **Repeat** option is set to **No**. Then select **Impair**.



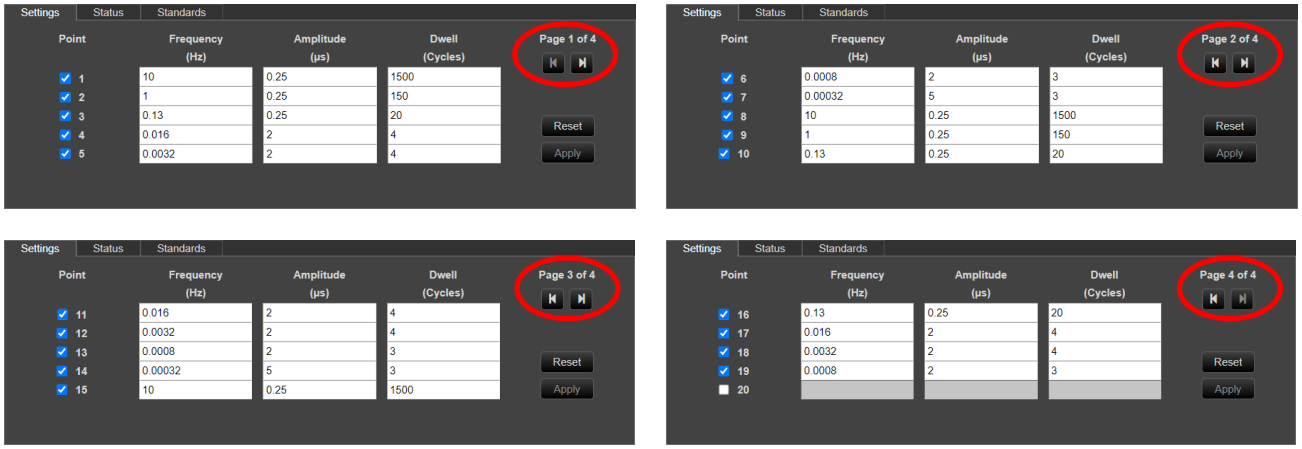
While running, the **Status** tab will show progress through the impairment pattern:



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



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.



7. 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.

8. From the **1pps Time Error Measurement + Time of Day** app selecting **Measure** then selecting **CAT** will launch the Calnex Analysis Tool.

9. Launch **CAT** at any time to monitor the DUT 1pps output timing performance.

10. Monitor the DUT to confirm it has not raised alarms, switched reference, or entered holdover.

11. Monitor the **Time Remaining** indicator on the **PTP Impairments** app, when the indicator stops counting down **Stop** the 1pps measurement.

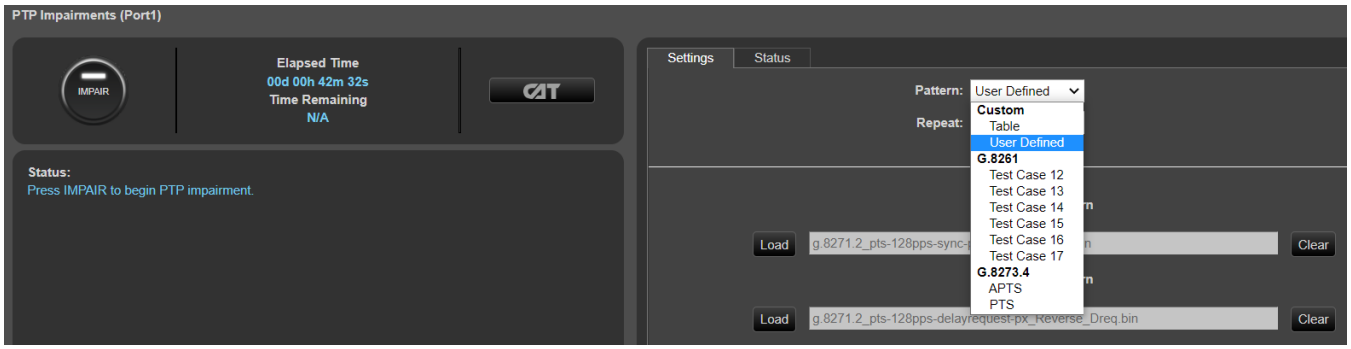
12. Launch the **CAT**. **Pass/Fail for the Max |TE$_L$| metric** for the 1pps output can be determined by enabling the **Time Error (Filtered)** metric. Then, apply the limit of **1.35µs** in the **Parameters** section in the bottom-right of the **CAT**.

13. Review the status and error logs of the DUT if they are available to confirm it has not raised alarms, switched reference, or entered holdover since the initial stabilisation period.

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-neo 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.

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

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.

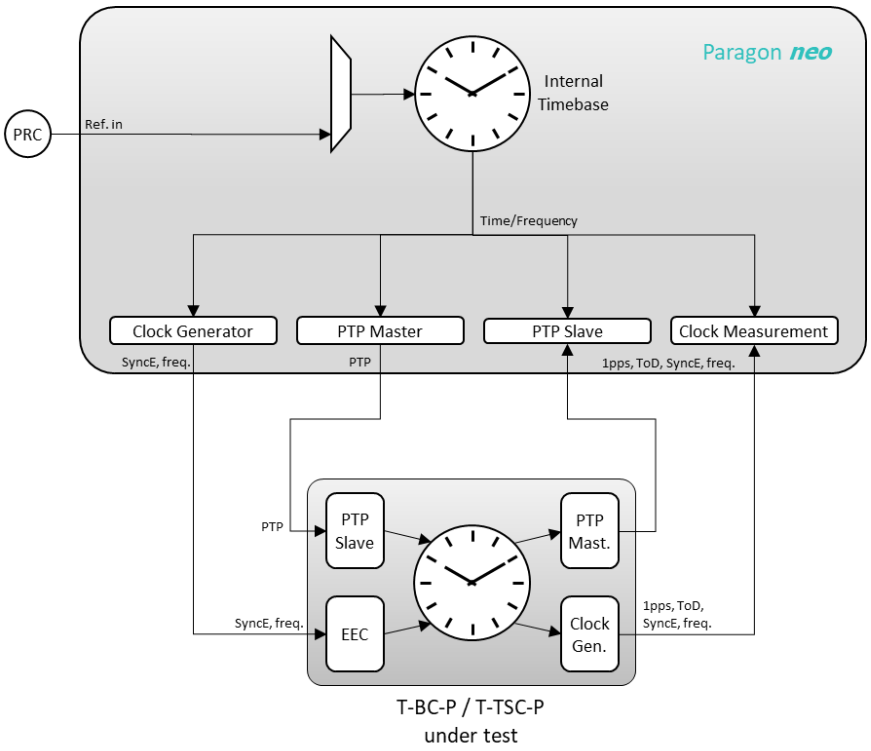
The specification should be viewed not a testable requirement but rather as an indication to the designer that amplifying the input signal is not permitted.

15. 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: one with loss of all references with an allowance for an initial transient of 22ns followed by a drift to 1.0278µs µs over the subsequent 1000s and a 22ns transient when exiting holdover; and one where there is a frequency (e.g. SyncE) reference available, with 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 ***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.

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.

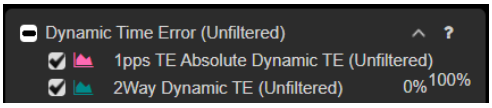
1. From the PTP Emulation app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run.

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.

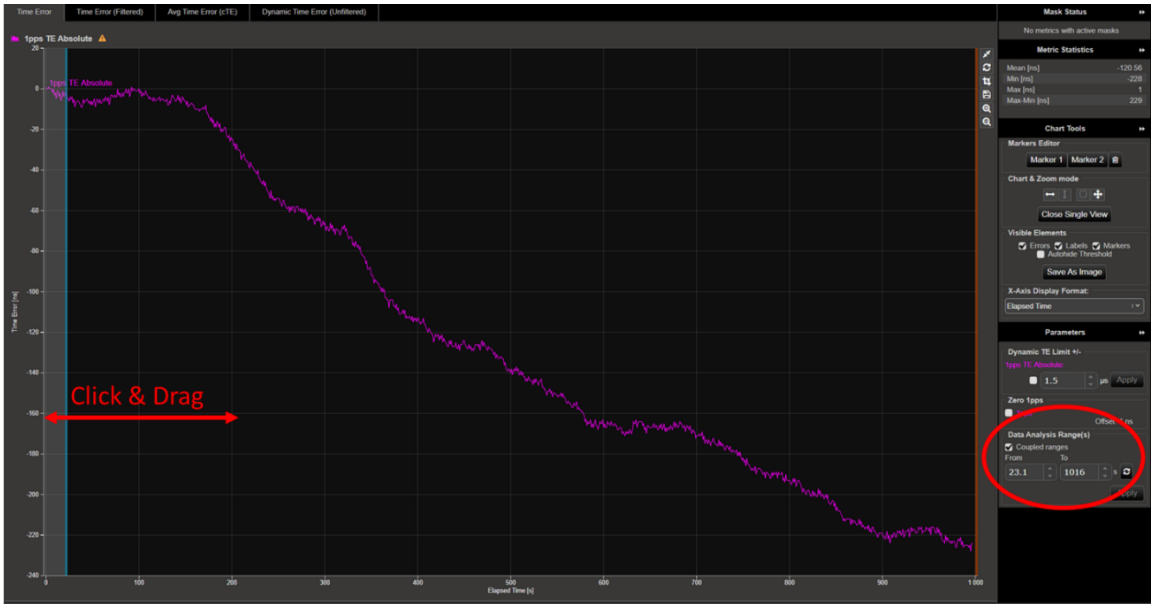
4. Allow the measurement to continue for 1000s then restore the PTP reference source only. Wait for the DUT to lock to the PTP input, then **Stop** the measurement.

5. 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:

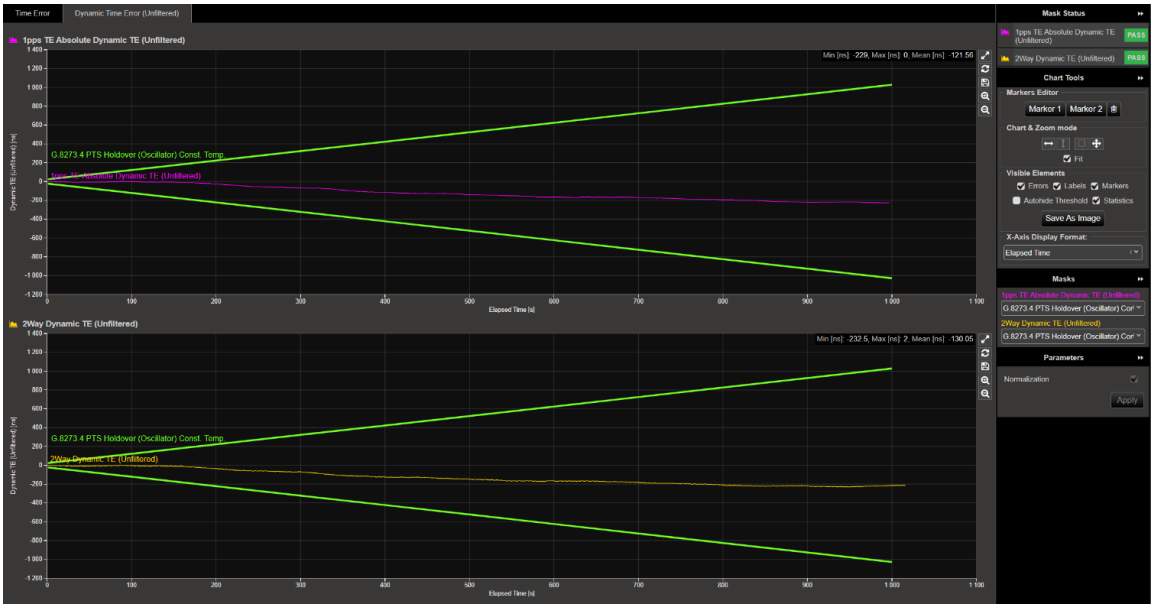


6. In **CAT** select the **Dynamic Time Error (Unfiltered)** tab and apply the **G.8273.4 PTS Holdover (Oscillator) Const. Temp.** mask.

7. If there is a noticeable transient in the plot at the point of the reference-removed event this should be aligned with the lowest point of the mask. To do this 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.

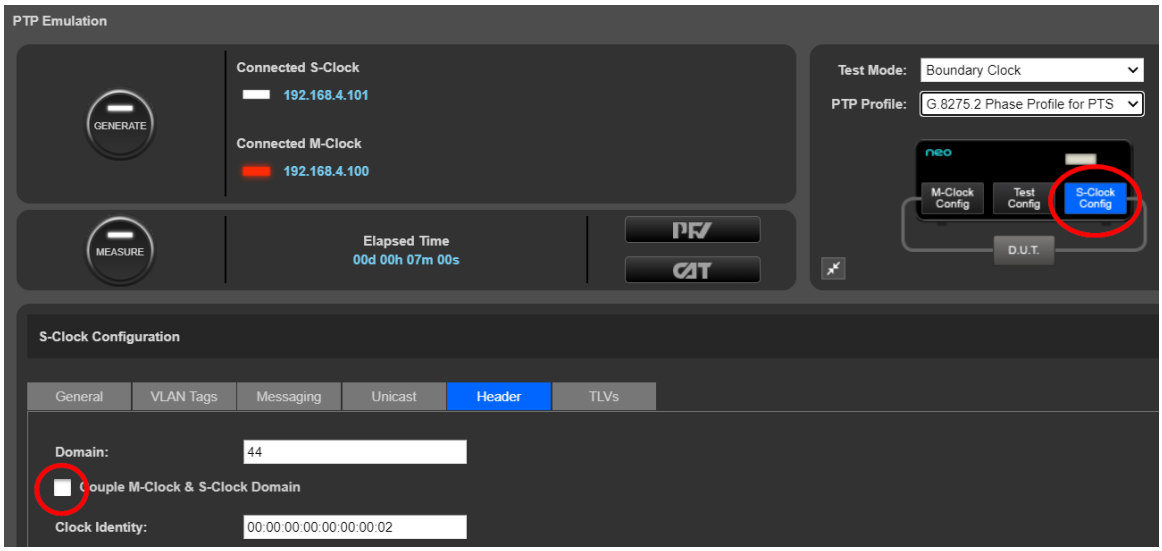


8. Select the **Dynamic Time Error (Unfiltered)** tab, check for PASS/FAIL against the configured limits. If the results pass then the status in the **Mask Status** Block will indicate PASS. Mask failure will be indicated by FAIL.



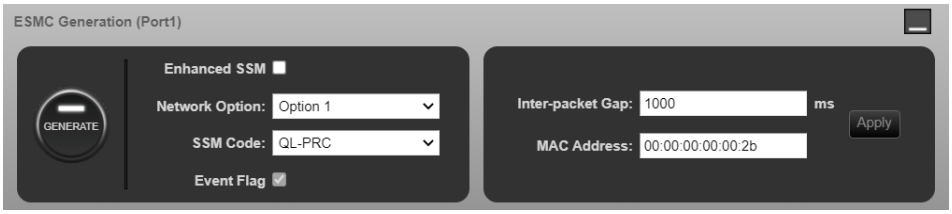
Phase Transient and Holdover based on physical layer frequency assistance (Clause 8.5.1 & 8.6.2)

Note: If SyncE is required, both SyncE and PTP are presented to the DUT on the same cable from Paragon-neo. To cause the DUT to reject only the PTP input while measuring the DUT PTP output, it is required to decouple the M-Clock and S-Clock PTP domains so that a non-matching domain can be configured on only the M-Clock. This is done by unchecking the *Couple M-Clock and S-Clock Domain* checkbox in the **S-Clock Config - Header** Tab. Setting the M-clock domain on Paragon-neo to a value other than initially configured value (by default 44) will ensure that the DUT ignores the PTP input from Paragon-neo and will enter the required holdover state.



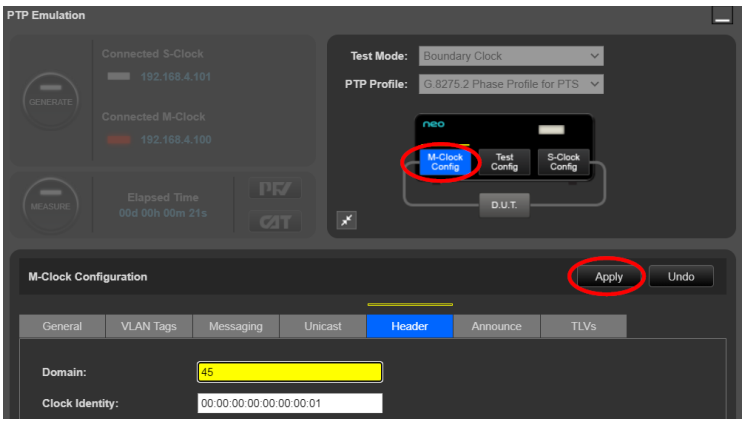
1. From the PTP Emulation app, press **Generate** and confirm that the appropriate settings have been made on Paragon-neo and the DUT to allow the PTP session to run.

2. 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**.



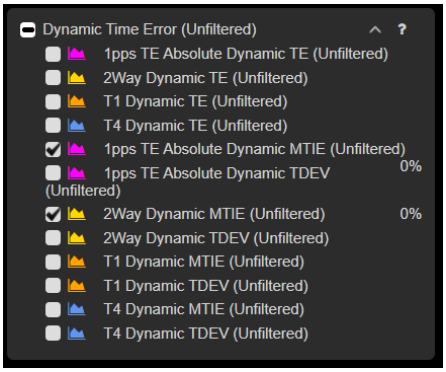
3. Select **Measure** on the relevant measurements (i.e. PTP, 1pps) then select **CAT** to launch the Calnex Analysis Tool, verifying that the device timing output is stable and ready to test – this may take up to one hour, dependent on the DUT, once the device is stable **Stop** all measurements.

4. 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 in on the same cable, by reconfiguring the Paragon-neo *M-Clock Domain* to a different value (e.g. change from 44 to 45).

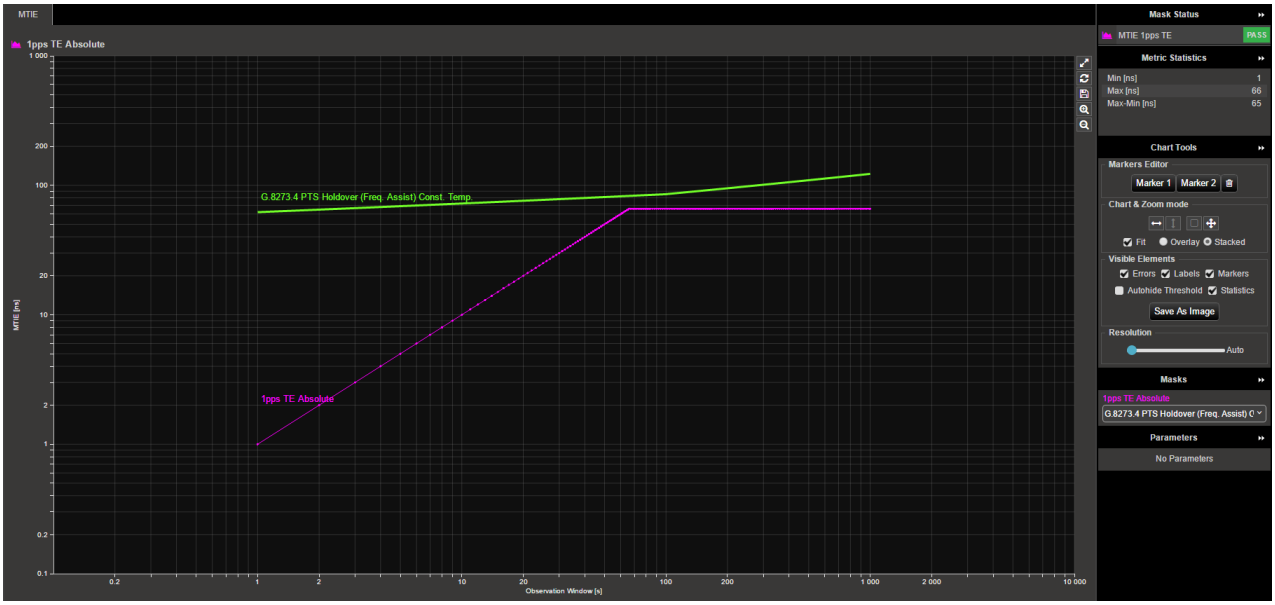


5. Confirm the frequency input is still selected by the DUT. Allow the measurement to continue for 1000s then restore the PTP reference source by reconnecting the cable or setting the *M-Clock PTP Domain* back to the value it was set to at the start of the test (default value 44). Wait for the DUT to lock to the PTP reference source then **Stop** the measurement.

6. 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:



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



8. Check for PASS/FAIL against the configured limits. If the results pass then the status in the **Mask Status** Block will indicate PASS. Mask failure will be indicated by FAIL.

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