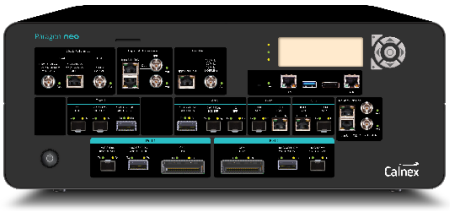
TEST GUIDE

CX3010 v4.0

G.8262.1/G.8262 EECs Conformance Test

Testing eEECs/EECs as per ITU-T G.8262.1/G.8262 using Paragon-neo

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



This Test Guide shows how the Paragon-neo can be used to perform the tests specified in the ITU-T G.8262.1/G.8262 standards for proving SyncE wander and jitter performance at rates up to 400GbE. The tests include noise generation, noise tolerance and transfer, phase transient response and holdover performance. These are compulsory tests for SyncE equipment or systems, with performance criteria for both standard and enhanced EECs.

Contents

1. Hardware and Software Required

Paragon-neo

Software version: 11.00.XX and later.

The table below shows the options required to perform EEC and eEEC conformance testing.

Opt. NEO-1G-10G Opt. NEO-25G Opt. NEO-40G Opt. NEO-50G Opt. NEO-100G	NRZ optical interface options.	At least one of these options must be fitted.
Opt. NEO-A-50G Opt. NEO-A-100G Opt. NEO-A-200G Opt. NEO-A-400G	PAM4 optical interface options.	
Opt. NEO-SyncE-Wander	SyncE Wander and ESMC test to ITU-T G.8262.1 and G.8262, including MTIE and TDEV analysis.	
Opt. NEO-SyncE-MTIE-TDEV	G.8262 MTIE and TDEV Wander Generation	Optional, improves test coverage.
Opt. NEO-SyncE-Jitter-XX	SyncE Jitter	Specific option depends on required interface type.

Accessories

- Optical Transceivers as required – recommended optics lists are available for Jitter testing at this **link.**
- Cables as required.

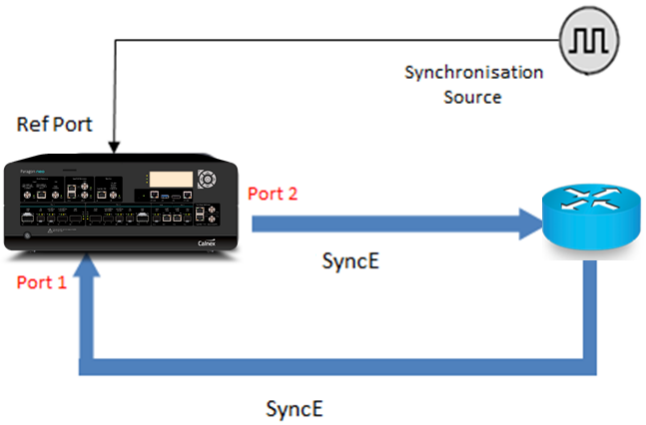
Document References

- Recommendation ITU-T G.810 definitions and terminology for synchronization networks
- Recommendation ITU-T G.8262.1 Timing characteristics of Enhanced EEC (eEEC)
- Recommendation ITU-T G.8262 Timing characteristics of Ethernet Equipment Clock (EEC)
- Recommendation ITU-T G.8261 Timing and synchronization aspects in packet networks

2. Connecting an eEEC/EEC to Paragon-neo

The basic physical connections between Paragon-neo and the DUT are shown below, any changes to this are detailed in the relevant section.

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



1. Connect Port 2 (jitter/wander generation side of Paragon-neo) to the DUT SyncE reference (input) port
2. Connect Port 1 to the DUT SyncE output port, this is the SyncE signal to be measured
3. Connect an external PRC quality reference, e.g. 10MHz, to the Paragon-neo Reference input.

3. How to Configure the Paragon-neo for G.8262.1/G.8262 Wander Tests

The following steps are required to set up the Paragon-neo prior to performing G.8262.1/G.8262 Wander tests:

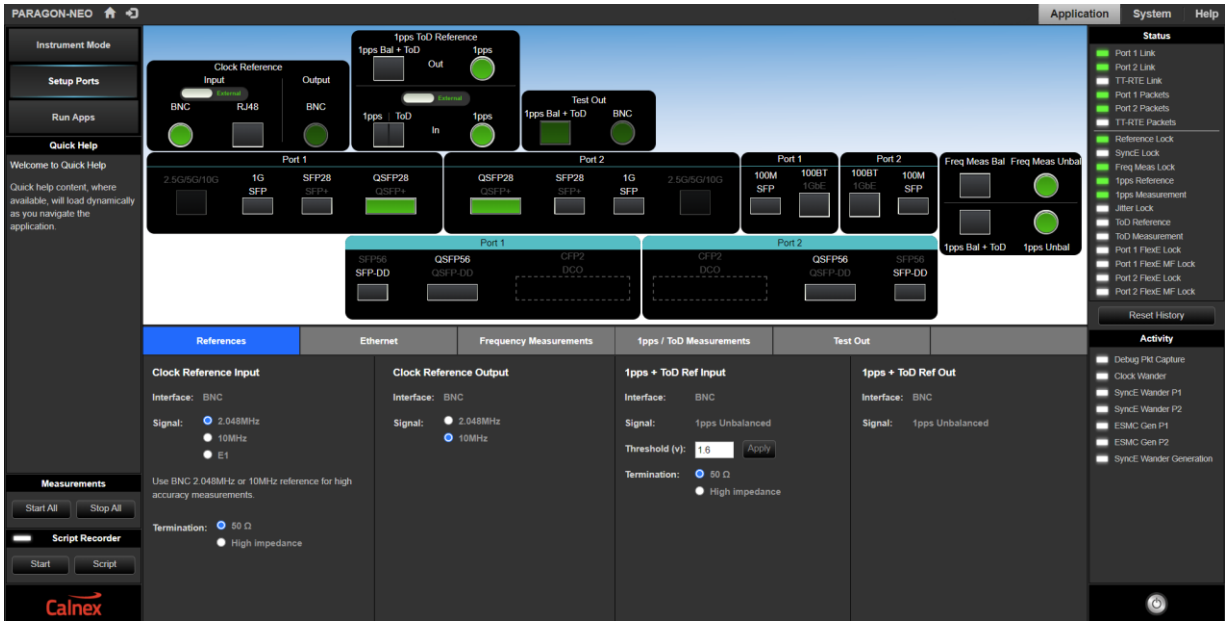
3.1. Connection to Paragon-neo
3.2. Configuration of Physical Connections
3.3. Test Configuration

3.1 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 **SyncE Wander** operating mode.
4. See the Paragon-neo Getting Started Guide for more details.

3.2 Configuration of Physical Connections

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

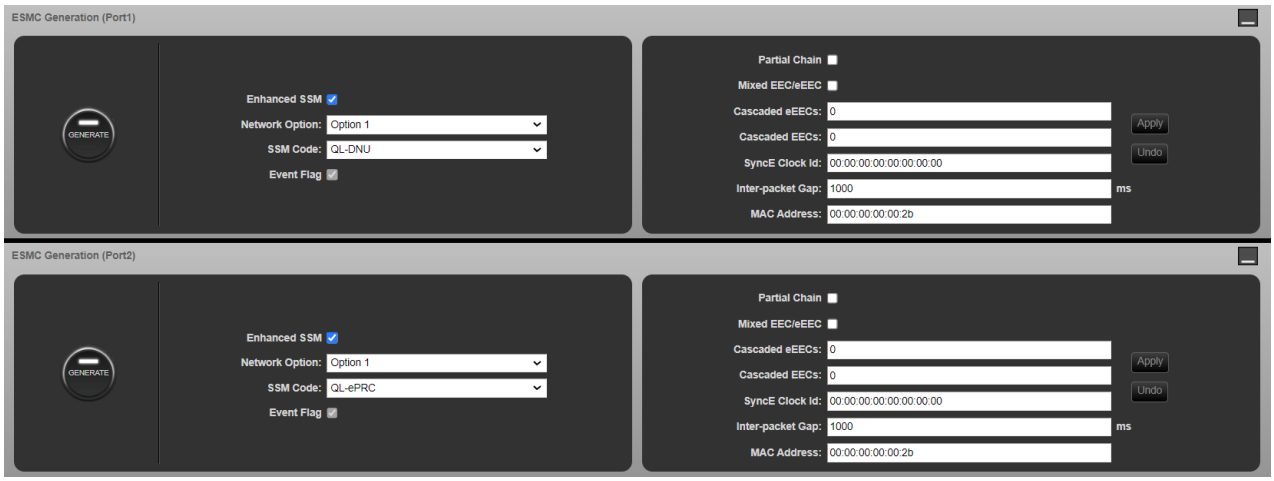


3.3 Test Configuration

1. Select the **Run Apps** page. if the presets are not already displayed, expand the Presets panel, then select the **SyncE Wander** preset.

Note: Once you have selected this, the status of **Port 1/Port 2 Link** and **Port 1/Port 2 Packets** should be green. The **Reference Lock** should be green.

ESMC Generation



The Paragon-neo can generate ESMC messages on both Ports 1 and 2. For SyncE conformance testing, ESMC messages are generated on Port 2 with a user-defined Quality Level (QL) such as PRC.

2. Navigate to the panel **ESMC Generation Port 2**, this is the output from the Paragon-neo and input to eEEC/EEC.
3. By default, Paragon-neo is configured to use Enhanced SSM message formats. Unselecting the tick-box configures Paragon-neo to generate standard SSM message format.
4. Selecting the desired **Network Option** from the drop-down menu pre-populates the appropriate range of SSM codes.

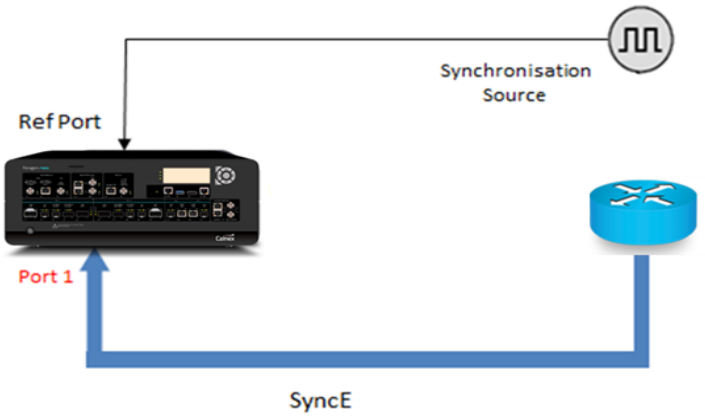
   Note: The Network Option should match that of the DUT to ensure that the SSM code is correctly processed by the DUT.

5. Set **SSM code** to e.g. QL-PRC, which tells the eEEC/EEC that the clock from the Paragon-neo is of PRC quality.
6. Generate ESMC messages by selecting the 

button. The button LED will turn green to indicate the Paragon-neo is generating ESMC packets.

   Note: After any setup changes to the Paragon-neo, ensure the device under test has had time to settle before making any measurements.

4. Measuring Frequency Accuracy – G.8262.1/G.8262 Section 6



	Stimulus / DUT Mode	Pass/Fail Criteria	Notes
eEEC and **EEC Option 1**	Free run	±4.6ppm	See full notes in the section "Testing Option 1 Clocks", below.
EEC Option 2	Prolonged Holdover	±4.6ppm	See full notes in the section "Testing Option 2 Clocks", below.

Testing Option 1 Clocks

ITU-T G.8262 clause 6.1 specifies the clock be tested *"under free-running conditions"*.

ITU-T G.810 clause 4.4 defines freerun as *"the operating condition of a clock that has never had an external reference input, or the clock has lost external reference and has no access to stored data that could be acquired from a previously connected external reference"*. One method to put a clock into the freerun condition is to disconnect all external references, power cycle the device, then wait for it to boot and the oscillator to fully warm up.

ITU-T G.8262 for Option 1 clocks states: *"The time interval for this [frequency] accuracy is for further study. Values of one month and one year have been proposed"*, as it is usually unfeasible to test for this amount of time, Calnex recommends a test time of 72 hours. If, after a 72 hour test, the maximum FFO value is not close to the limit and is not still increasing then it can be reasonably assumed that the clock is within the frequency accuracy specification.

Testing Option 2 Clocks

ITU-T G.8262 clause 6.2 the operating mode is specified as *"under prolonged holdover conditions"*, with the initial holdover condition being entered after the device has been locked (synchronised operation) for 30 days.

ITU-T G.810 clause 4.4 defines holdover as the operating condition of a clock that was previously locked to an external reference input but has now lost this reference and is currently using stored data acquired while in locked operation to adjust the oscillator. After entering the holdover condition the accuracy of the clock will not degrade immediately, however as the time spent in holdover increases, the influence of the stored data is reduced, and the frequency accuracy of the clock will degrade. See section 12 in this document for information regarding the steps to put a device into the holdover condition.

G.8262 does not specifically state at which point in time after holdover is entered that the frequency accuracy is to be measured, and as explained, this accuracy will degrade over time. The term *"prolonged holdover conditions"* is not formally defined however a reasonable interpretation is: the timeframe after which the frequency drift caused by

oscillator ageing begins to dominate the measurement. A typical timeframe for this to happen is around 48 hours after all references are lost for an EEC Option 2 quality oscillator, however this can vary significantly between devices.

Considering the complexities of the above, Calnex recommends first running the Option 2 test with the clock in freerun for 72 hours (see Option 1 clock test above) as this will test the oscillator in its least accurate state. If, after a 72-hour freerun test, the maximum FFO value is not close to the limit and is not still increasing then it can be reasonably assumed that the clock is within the frequency accuracy specification. If the clock does not pass under freerun conditions, then the "prolonged holdover test" below should be run.

ITU-T G.8262 for Option 2 clocks notes the specification is *"... over a time period T of one year"*. As it is usually unfeasible to test for this amount of time Calnex recommends 96 hours for the "prolonged holdover test", 48 hours after references lost, then an additional 48 hours.

If the clock does not pass the test above, then further analysis of the results and the device should be performed to gain a deeper understanding of the clock accuracy after it is put into the holdover condition, and how it subsequently degrades over time.

Use of FFO Metric

ITU-T G.810 defines Frequency Accuracy as the *"maximum magnitude of the fractional frequency deviation for a specified time period"*. Fractional frequency deviation, also known as fractional frequency offset (FFO) is the *"difference between the actual frequency of a signal and a specified nominal frequency, divided by the nominal frequency."* The Calnex CAT application applies the FFO metric and calculates the associated statistics, including the maximum.

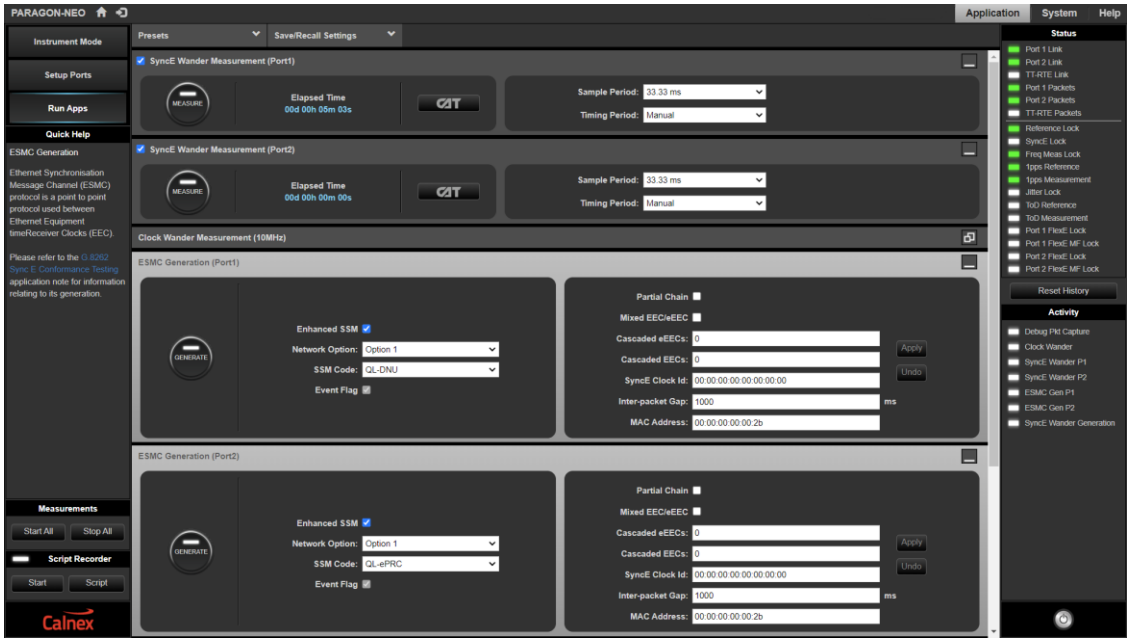
The FFO metric requires a regression time value to correctly estimate the accuracy of the clock, for eEEC/EEC clocks that are equivalent to a Stratum 3 clocks, the regression time has been taken from the GR-1244-CORE recommendation as 60 seconds.

Further information on this metric can be found at the following link:

https://calnexsolutions.atlassian.net/wiki/spaces/GDW/pages/78938264/What+is+Fractional+Frequency+Offset+Drift

Measurement Process

1. Connect the eEEC/EEC to Paragon-neo as shown above. Note that an external reference is mandatory
2. Set up the Paragon-neo GUI as described in Section 3.
3. Put the DUT into the appropriate mode (e.g. freerun) as described in the previous sections.
4. If not already selected, select **Run Apps.**



5. Select the 

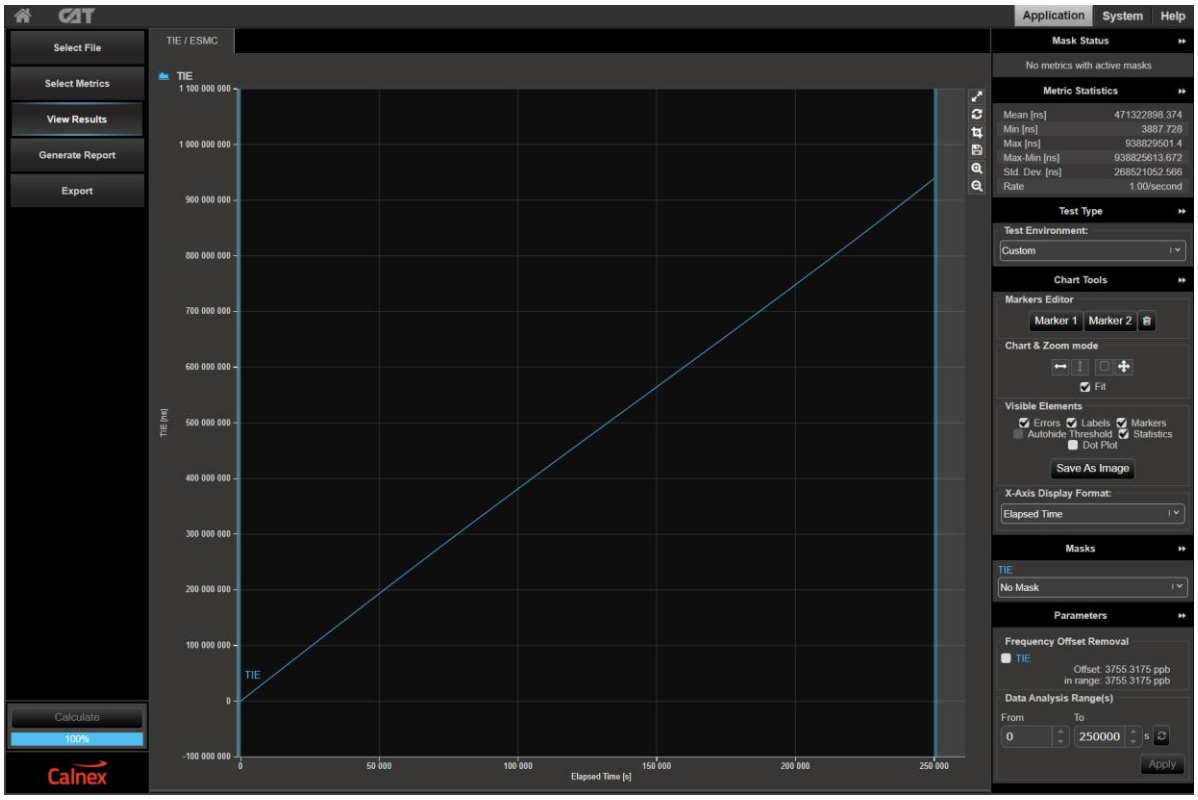
button on the connected port (Port 1) to start the measurement.
6. Test for the recommended test time as described in the previous sections:
    - 72 hours is recommended to test a clock in freerun.
    - 96 hours is recommended to test a clock in prolonged holdover conditions.

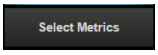
    The results can be viewed as the test is running by selecting 

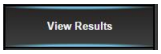
.
7. To stop the measurement, select the 

button.

8. Select  to pull up the results in a separate browser tab.



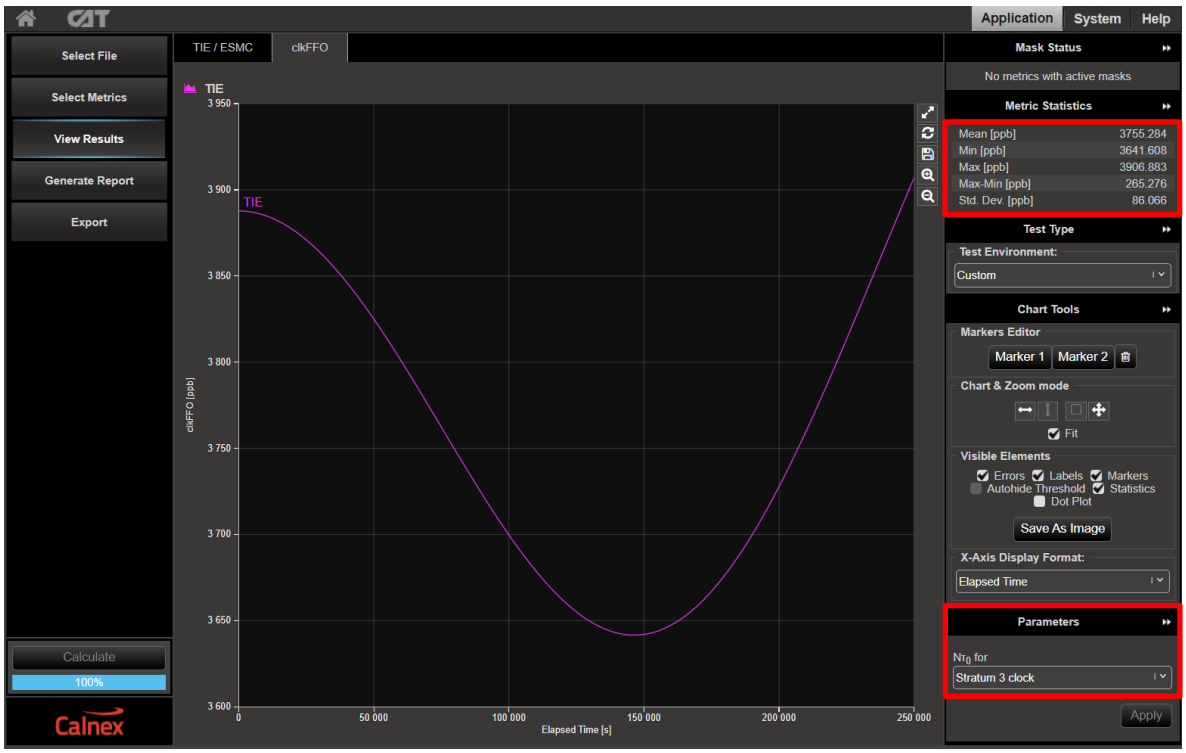
9. To display the FFO plot, press  then check the **clkFFO** tick box.

10. Select  on the left-hand side of the plot window, select **clkFFO** from the tabs at the top.

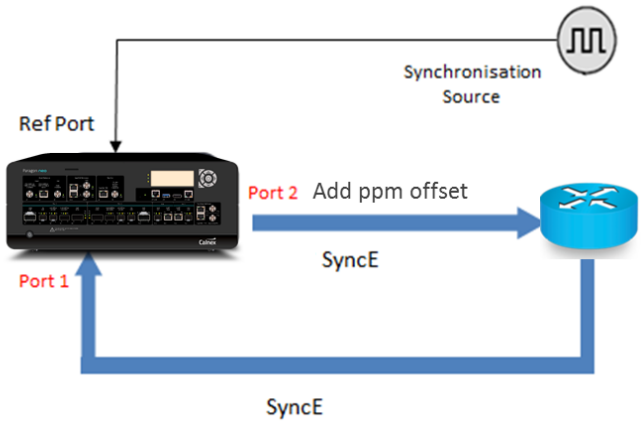
11. In the “Parameters” section in the lower right select **N_{T0} for “Stratum 3 clock”,** then click the Calculate button.

    The **clkFFO** metric plots the value of the FFO for the time corresponding time during the measurement, the maximum (worst-case FFO) is shown in parts-per-billion (ppb) in the **Max [ppb]** statistic.

    There is no automatic pass/fail for this metric, however, if the **Max [ppb]** value is between 4600 ppb (4.6ppm) and -4600 ppb (-4.6ppm) then the clock is within the specification and the test is a pass.



5. Pull-in, Hold-in and Pull-out Ranges – G.8262.1/G.8262 Section 7



Pull–in Range (G.8262.1/G.8262 Section 7.1)

The Pull-in range is defined as the largest offset between a subordinate clock's reference frequency and a specified nominal frequency, within which the subordinate clock will achieve locked mode.

	Input Stimulus	Pass/Fail Criteria	Notes
eEEC, **EEC Option 1** and **EEC Option 2**	Apply a large frequency offset ensuring eEEC/EEC is in holdover. Reduce offset until eEEC/EEC locks.	eEEC/EEC locks before offset reaches ±4.6ppm.	Lock can also be monitored by using ESMC (if supported).

Hold–in Range (G.8262.1/G.8262 Section 7.2)

Hold-in range is defined as the largest offset between a subordinate clock's reference frequency and a specified nominal frequency, within which the subordinate clock maintains lock as the frequency varies arbitrarily slowly over the frequency range.

	Input Stimulus	Pass/Fail Criteria	Notes
eEEC and **EEC Option 1**	Not Applicable		
EEC Option 2	EEC is locked to the clock from the Paragon-neo. The frequency is then offset to ±4.6ppm.	EEC should remain locked at an offset of ±4.6ppm.	Lock can also be monitored by using ESMC (if supported).

Pull–out Range (G.8262.1/G.8262 Section 7.3)

Pull-out range is defined as the offset between a subordinate clock's reference frequency and a specified nominal frequency, within which the subordinate clock stays in the locked mode and outside of which the subordinate clock cannot maintain locked mode, irrespective of the rate of the frequency change.

	Input Stimulus	Pass/Fail Criteria	Notes
eEEC and **EEC Option 1**	eEEC/EEC is locked to the clock from the Paragon-neo. The frequency is then offset until the eEEC/EEC unlocks.	EEC should remain locked at an offset of ±4.6ppm but lock should extend beyond this.	G.8262.1 and G.8262 state this is for further study.
EEC Option 2	Not Applicable		

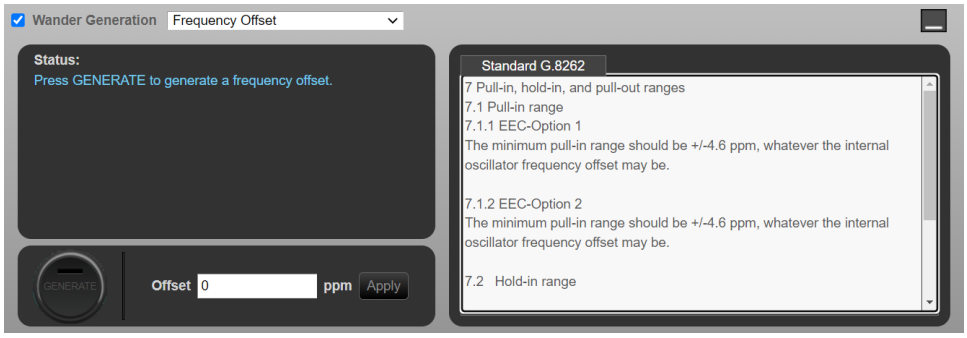
Measurement Process

1. Connect the eEEC/EEC to the Paragon-neo as shown in the diagram at the beginning of this section.
2. Set up the Paragon-neo as described in Section 3, including setting up ESMC with the following settings if using ESMC to monitor if the eEEC/EEC is switching clock references or going into holdover:

Clock Type	Network Option	SSM Code
eEEC	Option 1	QL-PRC
EEC	Option 1	QL-PRC
EEC	Option 2	QL-PRS

3. Select the 

button on Port 1 to start the measurement.
4. Select **Wander Generation** then select **Frequency Offset** in the drop-down menu.



5. In the Offset window, add the Frequency Offset required and click the 

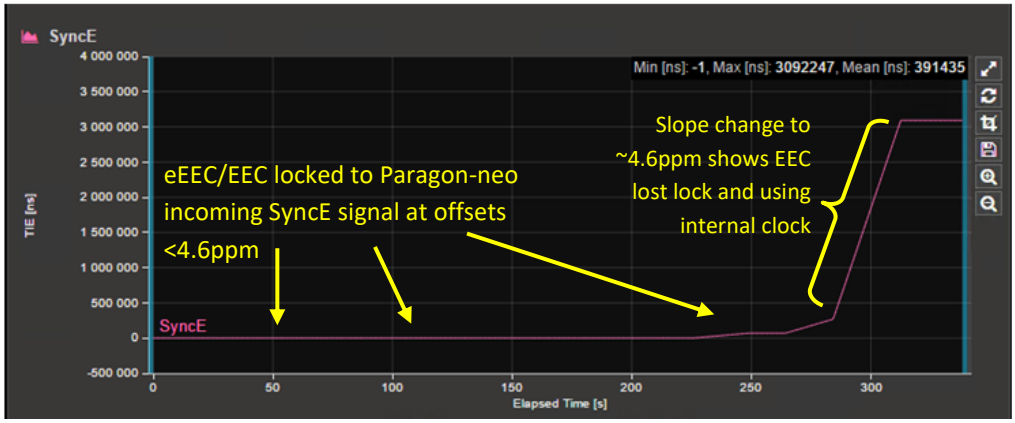
button.
6. To stop the measurement after the desired test duration, select the 

button.
7. Select 

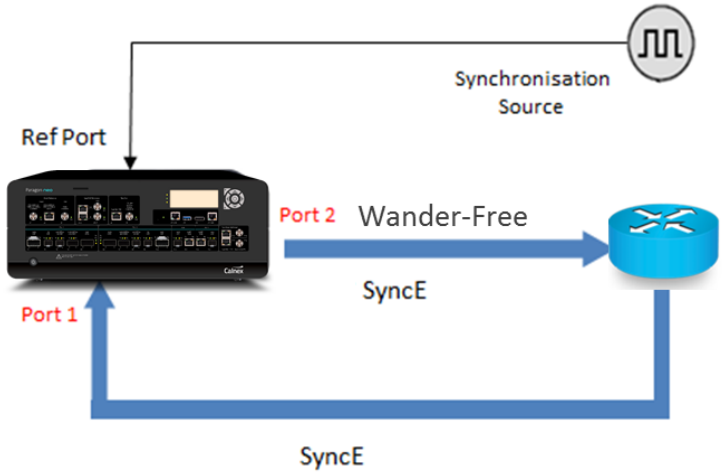
to pull up the results in a separate browser tab.

8. The Paragon-neo TIE graph indicates if the eEEC/EEC is in or out of lock as shown below.

   Note: The capture below shows an example of an EEC tracking lower frequency offsets, then rejecting a high frequency offset to use its internal clock. Actual behaviour may vary between devices.



6. Wander (Noise) Generation – G.8262.1/G.8262 Section 8



	Input Stimulus	Pass/Fail Criteria	Notes (G.8262.1/G.8262 masks)
eEEC (Constant Temp)	• Locked Mode • Wander Free reference • Constant temperature	MTIE and TDEV Pass/Fail masks shown in **G.8262.1** Section 8.1	G.8262.1: MTIE – Table 1, Figure 1 TDEV – Table 2, Figure 2
EEC Option 1 (Constant Temp)	• Locked Mode • Wander Free reference • Constant temperature	MTIE and TDEV Pass/Fail masks shown in G.8262 Section 8.1.1	G.8262: MTIE – Table 1, Figure 1 TDEV – Table 3, Figure 2
EEC Option 1 (Temp effects)	• Locked Mode • Wander Free reference • Temperature effects	MTIE Pass/Fail masks shown in G.8262 Section 8.1.1	G.8262: MTIE – Table 2, Figure 1 TDEV – G.8262 states for further study
EEC Option 2 (Constant Temp)	• Locked Mode • Wander Free reference • Constant temperature	MTIE and TDEV Pass/Fail masks shown in G.8262 Section 8.1.2	G.8262: MTIE – Table 4, Figure 3 TDEV – Table 5, Figure 4

G.8262 Section 8.2 also mentions measurements in non-locked mode and refers to Section 11.2 “Long-term phase transient response (Holdover)”. That scenario is covered in the corresponding section of this test guide. This scenario for eEEC is for further study.

Measurement Setup

1. Connect the eEEC/EEC to Paragon-neo as shown in the diagram at the beginning of this section.
2. Set up the Paragon-neo as described in Section 3, including setting up ESMC with the following settings if using ESMC to monitor if the eEEC/EEC is switching clock references or going into holdover:

Clock Type	Network Option	SSM Code
eEEC	Option 1	QL-PRC
EEC Option 1	Option 1	QL-PRC
EEC Option 2	Option 2	QL-PRS

Measurement Process

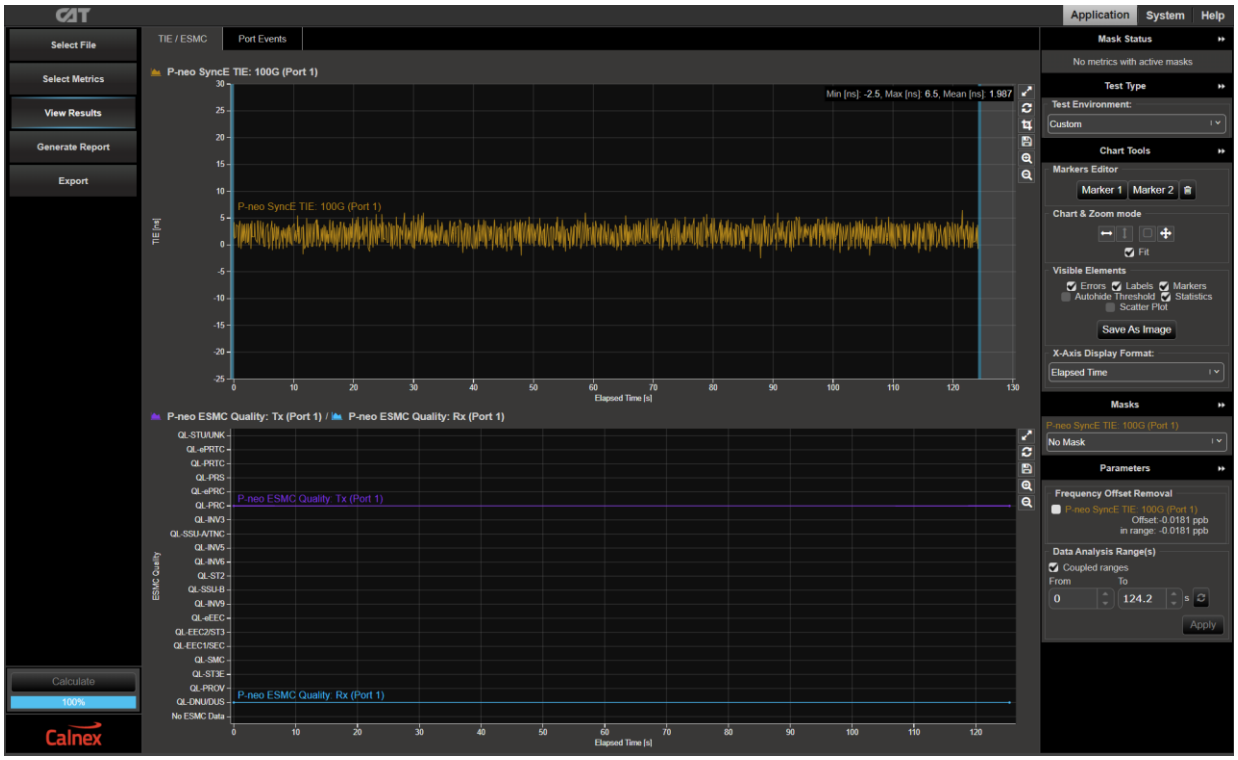
1. Select the 

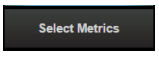
button on Port 1 to start the measurement. To stop the measurement, select the 

button. It is suggested that the test should run for 3,000 seconds (50 minutes).

2. Select 

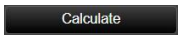
to view the results in a separate browser tab. The plots will show the captured TIE and the ESMC Rx and Tx.



3. To display the MTIE graphs, press 

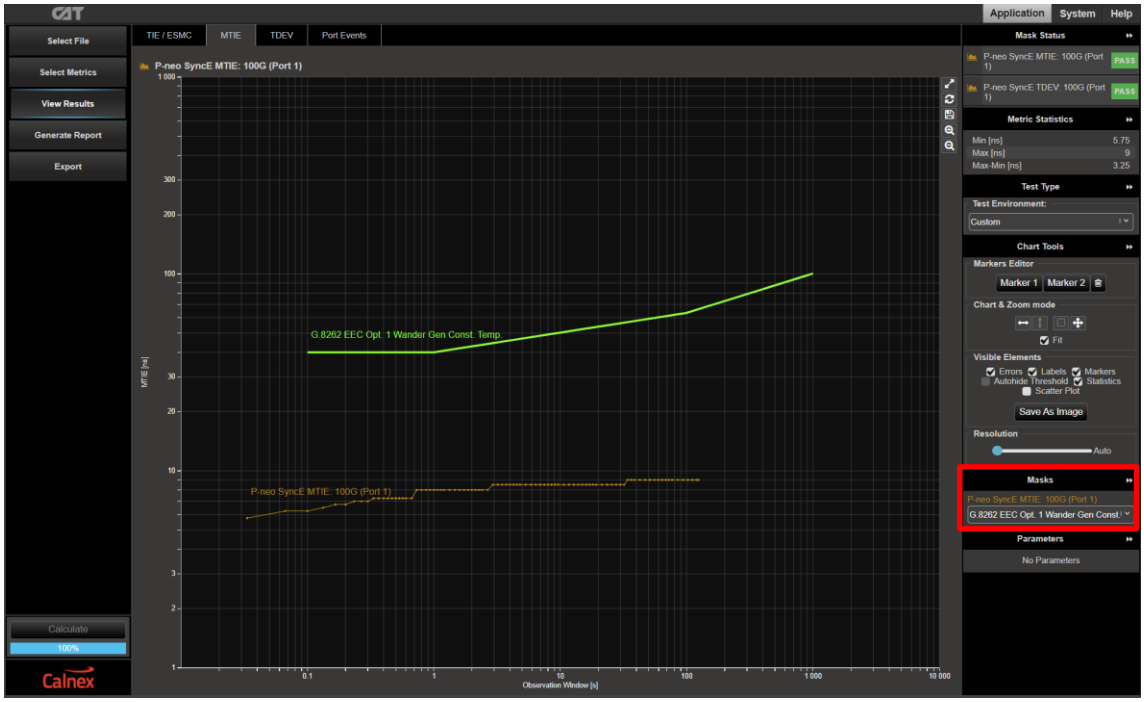
then check the MTIE and TDEV tick boxes.

4. Select 

on the left-hand side of the graph, select **MTIE** from the tabs at the top, then click the 

button.

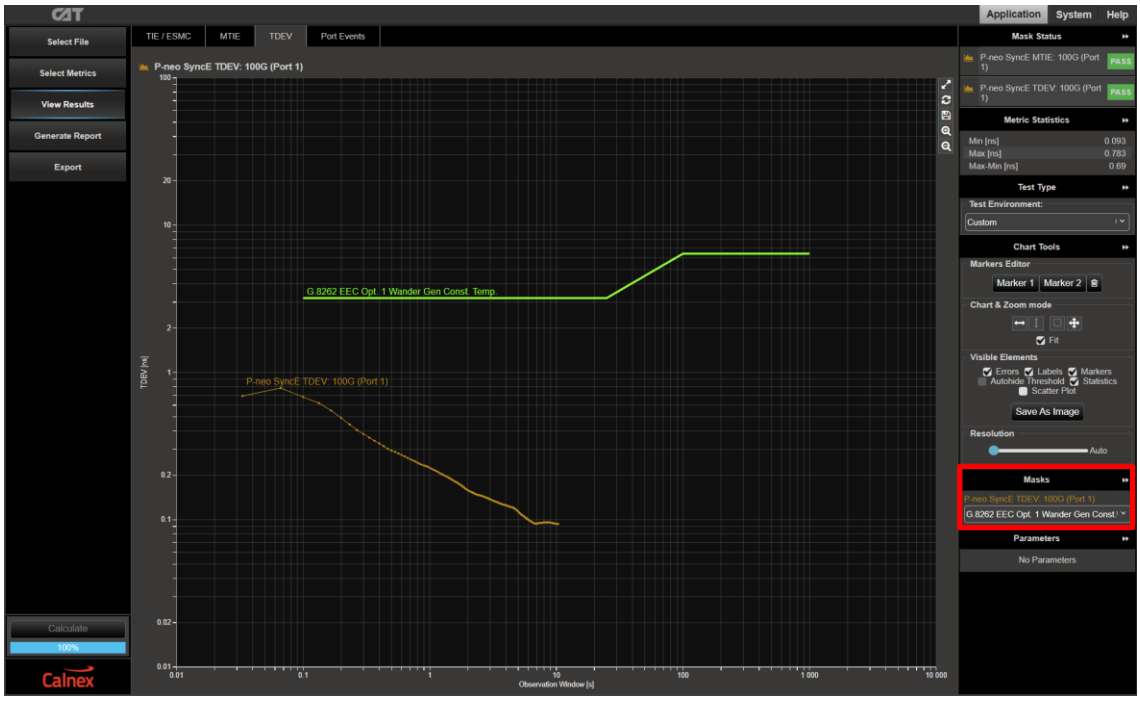
5. The **MTIE** results can be reviewed against the G.8262.1/G.8262 masks by selecting a mask from the Metric Mask pull down menu under **Masks** at the right of the graph.



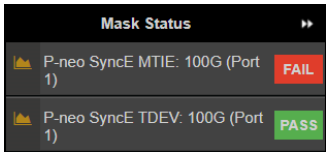
6. To display the TDEV graph, select **TDEV** from the tabs at the top.

7. The TDEV results can be reviewed against the G.8262.1/G.8262 masks by choosing a mask from the Metric Mask pull down menu under **Masks** at the right of the graph.

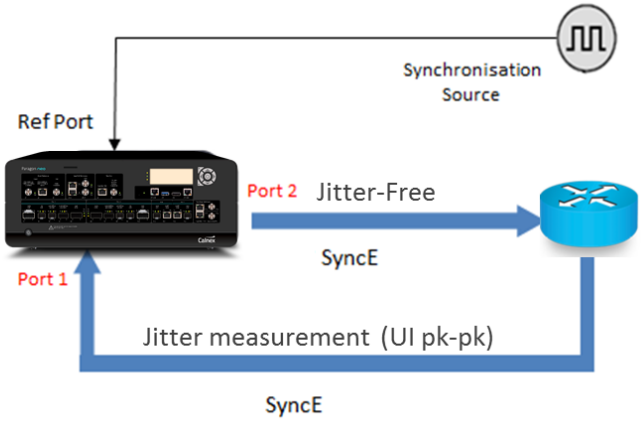
   If the mask selected in MTIE has a corresponding TDEV mask, this will automatically be applied.



8. Pass/Fail indication against the masks is shown in the top right under **Mask Status** with green highlight for a “Pass” red highlight for a “Fail”.



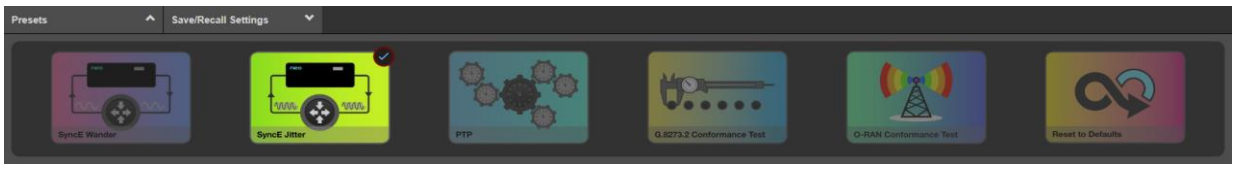
7. Jitter Generation – G.8262.1/G.8262 Section 8.3

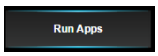


	Input Stimulus	Pass/Fail Criteria	Notes
1G	None, unless device requires packet stream to function.	**eEEC/EEC Output Jitter ≤0.5 UIpp** in 60-second window, as G.8262.1 8.3.1 Table 3, G.8262 8.3, Table 6.	
10G lanes (100GbE SR10, 40GbE, 10GbE)	None, unless device requires packet stream to function.	**EEC Output Jitter ≤0.5UIpp** in 60-second window, as G.8262 8.3, Table 6. **eEEC** performance is for further study in G.8262.1	For compatibility with EEC, testing eEEC pass/fail as per G.8262 is recommended.
25G lanes (100GbE SR/LR4, 25GbE SR/LR)	None, unless device requires packet stream to function.	**EEC Output Jitter ≤1.2UIpp** in 60-second window, as G.8262 8.3, Table 6. **eEEC** performance is for further study in G.8262.1	For compatibility with EEC, testing eEEC pass/fail as per G.8262 is recommended.

Measurement Setup

1. Connect the eEEC/EEC to Paragon-neo as shown in the diagram at the beginning of this section.
2. Set up the Paragon-neo as described in Section 3.
3. From the **Presets** panel, select **SyncE Jitter**.

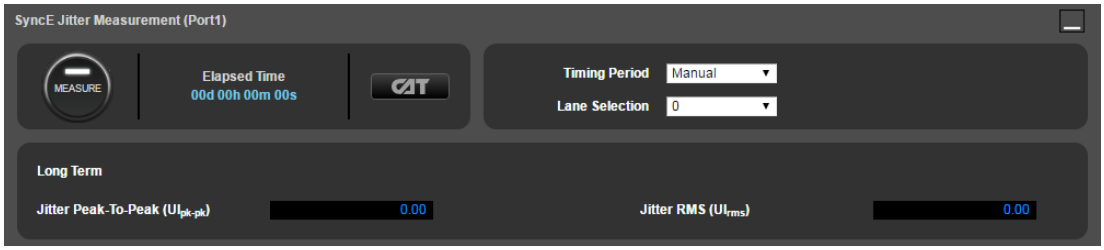


4. Select the 

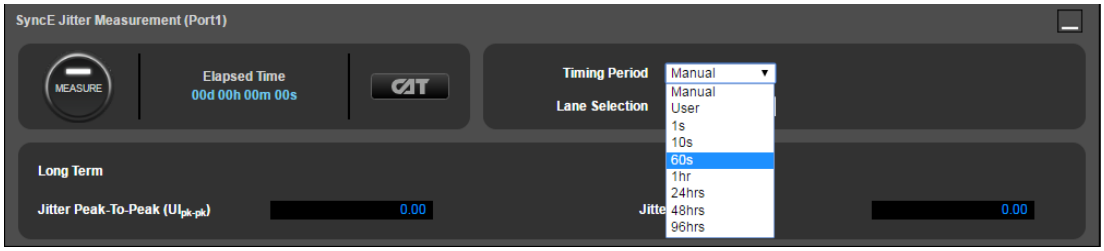
button on the Paragon-neo GUI.

Measurement Process

1. Select **Jitter Measurement**.

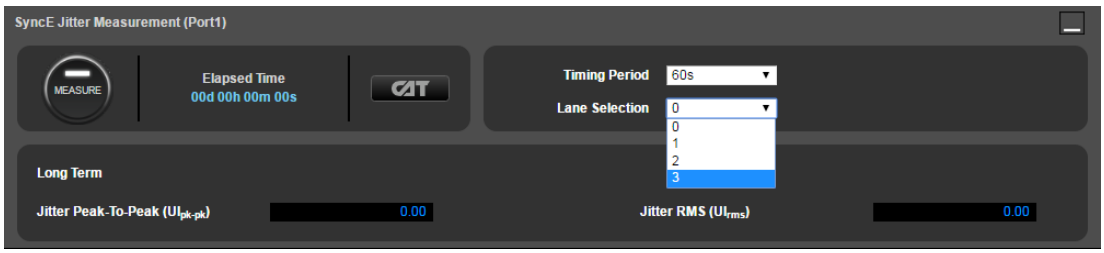


2. G.8262.1 and G.8262 specify a peak-to-peak (pp) jitter measurement time of 60s. Select **Timing Period**, **60s**.



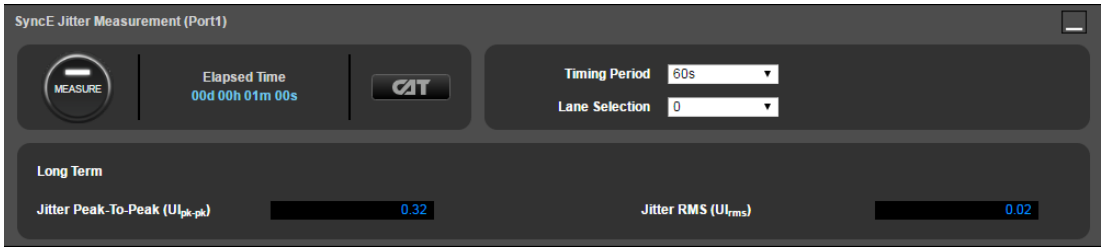
Select other periods or manual if required, for e.g. experimentation or observing long-term device behaviour. 60s must be selected for making a G.8262.1/G.8262 compliance measurement.

3. If multi-lane interfaces are being tested, select the required lane to be tested from the **Lane Selection** drop down. These could exhibit different jitter characteristics, and it is therefore recommended to verify jitter performance on each lane.

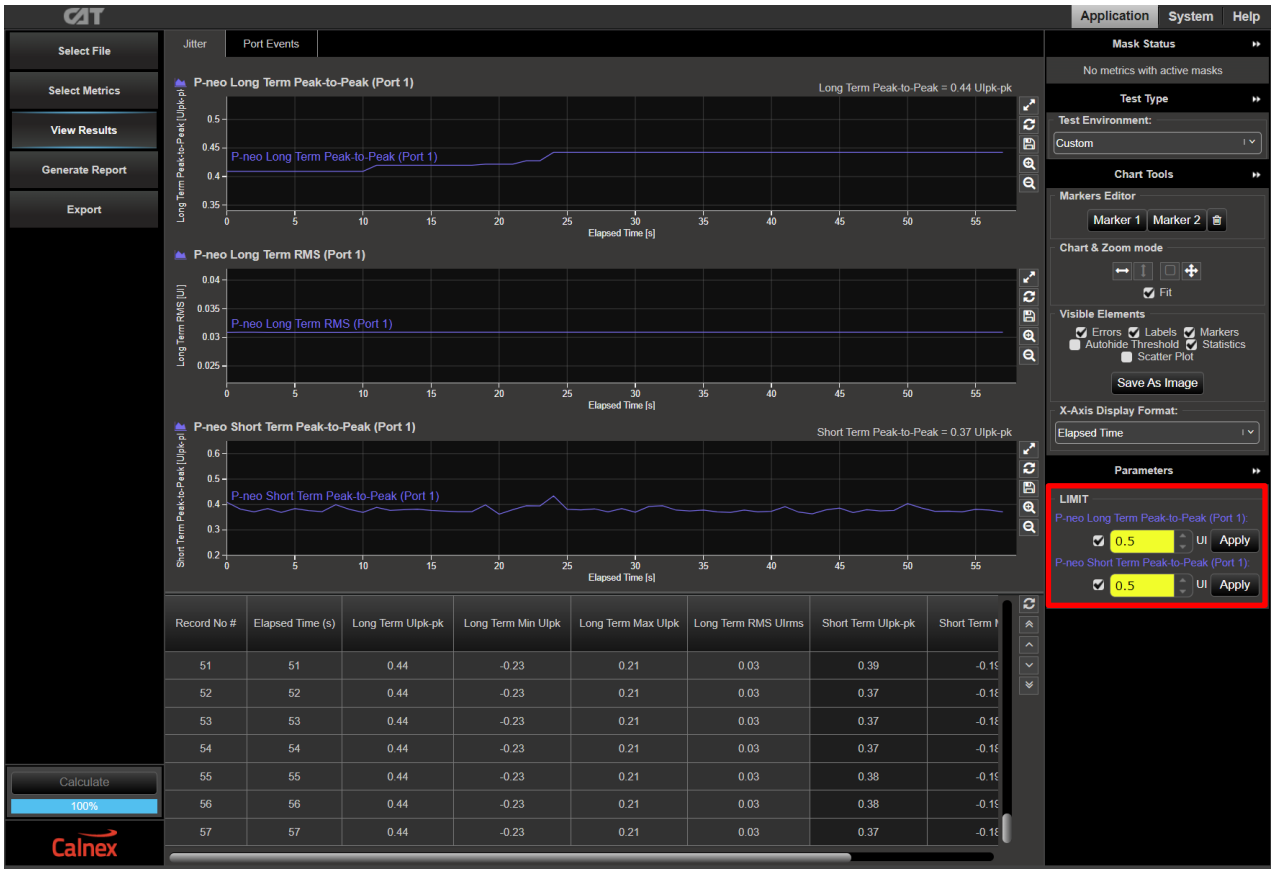


4. Select the 

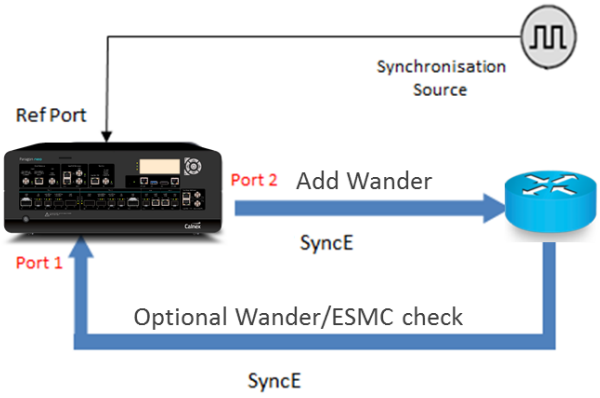
button on Port 1 to start the measurement. The results displayed are the peak to peak and RMS jitter values, they are calculated and displayed when the measurement is stopped.



5. Selecting  will show the results in a separate browser tab. This can be used further analyse the results if required, including adding limit thresholds.



8. Wander (Noise) Tolerance – G.8262.1 Sections 9.1, 9.2/G.8262 Section 9.1



	Input Stimulus	Pass/Fail Criteria	Notes
eEEC Level 1 [1]	G.8262.1: • MTIE Wander of G.8261 clause 9.2.1.4 Table 8, Figure 17	The eEEC must: • Maintain the clock within performance limits. • Not cause any alarms. • Not cause the clock to switch reference. • Not cause the clock to go into holdover.	To check whether the eEEC is switching references or going into holdover, the Paragon-neo can measure the wander and/or ESMC QL of the eEEC output.
eEEC Level 2 [2]	G.8262.1: • MTIE Wander Table 4, Figure 3 • TDEV Wander Table 5, Figure 4 • Sinusoidal Wander Table 6, Figure 5	The eEEC must: • Maintain the clock within performance limits. • Not cause any alarms. • Not cause the clock to switch reference. • Not cause the clock to go into holdover.	To check whether the eEEC is switching references or going into holdover, the Paragon-neo can measure the wander and/or ESMC QL of the eEEC output.
EEC Option 1	G.8262: • MTIE Wander Table 7, Figure 5 • TDEV Wander Table 8, Figure 6 • Sinusoidal Wander Table 9, Figure 7	The EEC must: • Maintain the clock within performance limits. • Not cause any alarms. • Not cause the clock to switch reference. • Not cause the clock to go into holdover.	To check whether the EEC is switching references or going into holdover, the Paragon-neo can measure the wander and/or ESMC QL of the EEC output.
EEC Option 2	G.8262: • TDEV Wander Table 10, • Figure 8	The EEC must: • Maintain the clock within performance limits. • Not cause any alarms. • Not cause the clock to switch reference. • Not cause the clock to go into holdover.	To check whether the EEC is switching references or going into holdover, the Paragon-neo can measure the wander and/or ESMC QL of the EEC output.

[1] A TDEV wander limit is specified in G.8261 clause 9.2.1.4, however the practical method to test (by counting transients) is for further study.

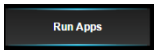
[2] A Level 2 eEEC as per G.8262.1 is intended to be capable of operating in a mixed network with EECs, and as such the input stimuli are the same as for an EEC Option 1 as per G.8262.

Measurement Setup

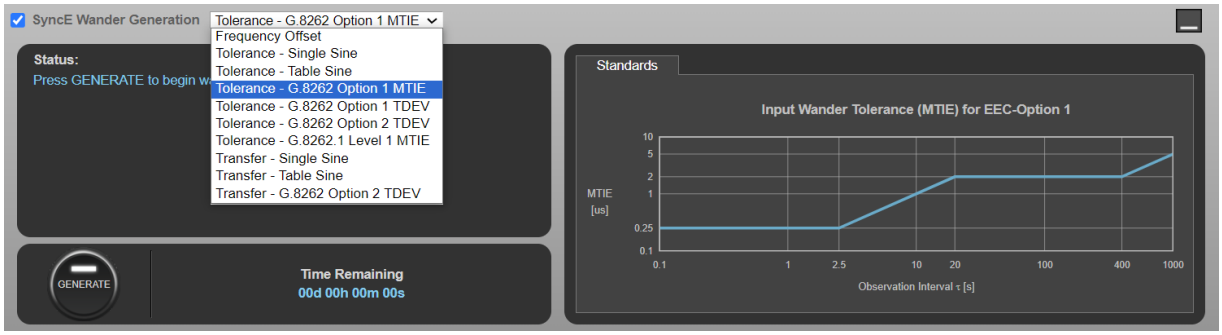
1. Connect the eEEC/EEC to Paragon-neo as shown in the diagram at the beginning of this section.
2. Set up the Paragon-neo as described in Section 3, including setting up ESMC with the following settings if using ESMC to monitor if the eEEC/EEC is switching clock references or going into holdover:

Clock Type	Network Option	SSM Code
eEEC	Option 1	QL-PRC
EEC Option 1	Option 1	QL-PRC
EEC Option 2	Option 2	QL-PRS

Measurement Process – Initial Setup

1. Select the 

button on the Paragon-neo GUI.
2. Select one of the Tolerance options in the **Wander Generation** pull down menu.



There are three methods of generating wander into the eEEC/EEC:

- **Tolerance MTIE/TDEV** wander (various options), the fastest and most effective way to evaluate eEEC/EEC performance.
- **"Tolerance Table Sine"** – applies a series of tones for wander tolerance or for finding maximum tolerable wander.
- **"Tolerance Single Sine"** – can be used for troubleshooting specific frequencies.

Measurement Process - MTIE/TDEV Wander

Paragon-neo can generate MTIE and TDEV Wander as defined in G.8262.1/G.8262. If your instrument does not feature MTIE/TDEV Wander Generation then you can use the Table Sine function, detailed in the next section.

1. Select the wander mask required from the pull down menu. The tolerance mask plot is shown on the right-hand side of the window. **Note that for testing eEEC Level 2, EEC Option 1 should be applied, they are identical.**
   - **Tolerance – G.8262 Option 1 MTIE** – Running Time is 1000s (16 mins 40 secs)
   - **Tolerance – G.8262 Option 1 TDEV** – Running Time is 12000s (3 hours 20 mins)
   - **Tolerance – G.8262 Option 2 TDEV** – Running Time is 12000s (3 hours 20 mins)
   - **Tolerance – G.8262.1 Level 1 MTIE** – Running Time is 11 days, 13 hours. 46 mins)
     - The duration of this pattern reflects the MTIE mask it is based upon; 4 hours test duration is recommended.
2. Under **Wander Generation**, click 

to start the test. The remaining time will be displayed beside the Generate/Stop button.
3. The test will stop automatically after the running time has elapsed. The test can also be stopped by selecting 

Measurement Process - Tolerance - Table Sine (Standards)

Used to apply a series of tones that have been chosen to meet the tolerance masks of the relevant ITU specifications. More information about the tones selected can be found at the following link:

https://calnexsolutions.atlassian.net/wiki/spaces/GDW/pages/10322571/What+Frequencies+should+be+used+for+testing+SyncE+Wander+Tolerance

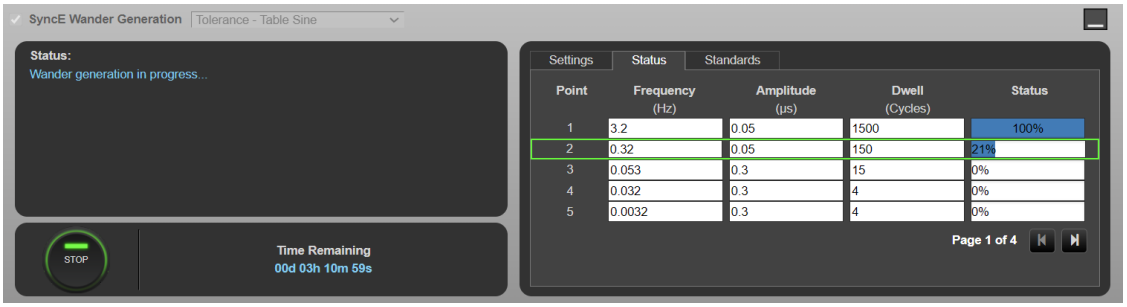
1. Select **Tolerance – Table Sine**. The **Standard** pull down menu is used to select the appropriate tones to meet the wander tolerance mask.

2. Select the wander tolerance mask required. The tolerance mask plot is shown on the **Standards** tab. **Note that for testing eEEC Level 2, EEC Option 1 should be applied, they are identical.**
   - **G.8262 Option 1** – Running Time is approx. 15000s (4 hours 12 mins)
   - **G.8262 Option 2** – Running Time is approx. 14000s (3 hours 58 mins)
   - **G.8262.1** – Running Time is 12000s (3 hours 20 mins)

3. Under **Wander Generation**, click 

to start to start the test. The remaining time will be displayed beside the Generate/Stop button.

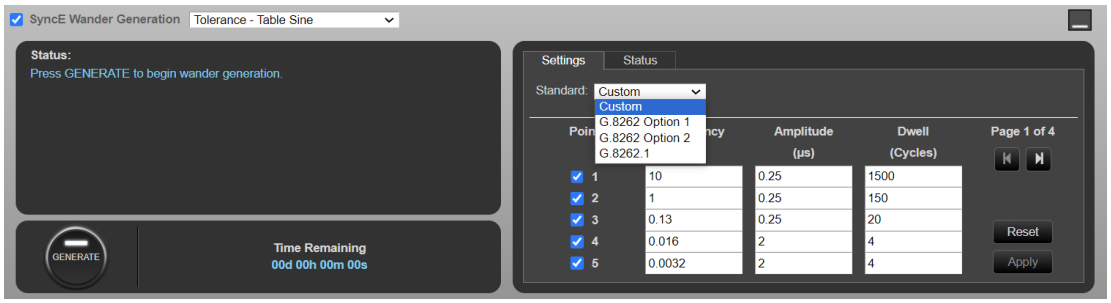
4. The Paragon-neo will then automatically generate each of the specified tones, showing progress in the Status column.



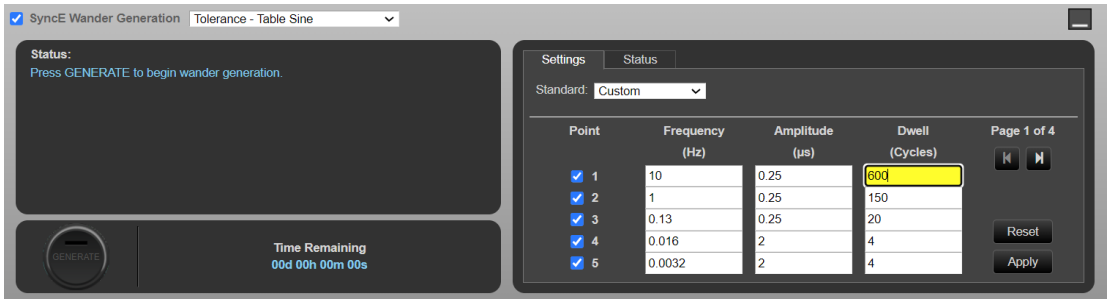
5. The test will stop automatically after the running time has elapsed. The test can also be stopped by selecting 

Measurement Process - Tolerance - Table Sine (Custom)

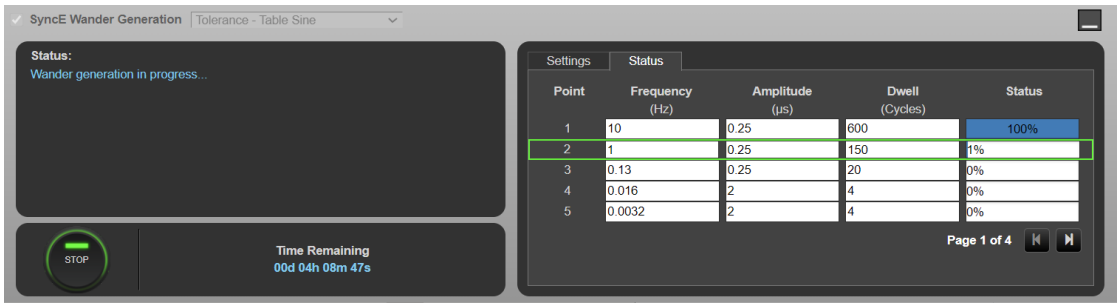
Can be used to test Maximum Tolerable Wander or for gaining more insights into the performance of the device under test. The frequencies used must be chosen carefully to avoid Nyquist effects due to sampling.



Up to 20 different wander parameter sets can be entered in the table.



The Paragon-neo will then automatically generate each of the specified wander sets in turn, showing progress in the **Status** column.



Switching between different sets is always done at a zero crossing to prevent phase steps. To change the Table values, under Settings:

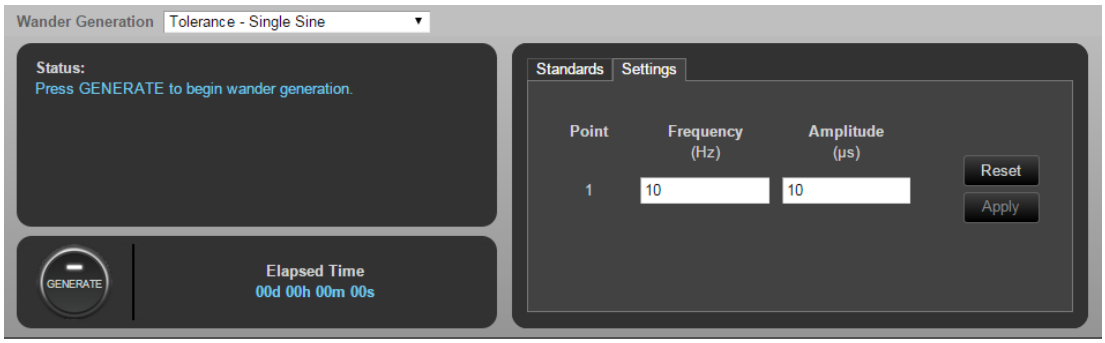
1. Enter the frequency, amplitude, and dwell time (number of cycles the frequency/amplitude pair will be run) for each wander test point.
   - The same frequency with different amplitudes can be entered to find maximum tolerable wander.
   - The **Reset** button, when checked, will restore the values to those defined in table 9 in G.8262.
   - Only rows that have the **Point** check box “ticked” will be executed in the test. To skip over a selection, untick the **Point** check box for that selection.
2. Under Wander Generation click 

to start the test.
3. The test can be stopped manually by selecting 

.The test will terminate at the next zero crossing.

Measurement Process - Single Sinusoidal Wander

Can be used for troubleshooting issues at a specific frequency.

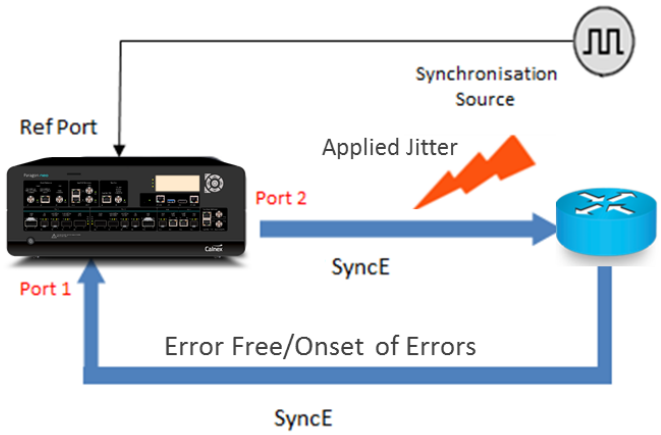


1. Enter the frequency and amplitude of the desired wander.
2. Click 

to start the test.
3. Click 

to stop the test. The test will terminate at the next zero crossing of the wander frequency, and a pop-up box stating how long to the next zero crossing is displayed.

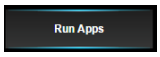
9. Jitter Tolerance – G.8262.1 Section 9.3, G.8262 Section 9.2



	Input Stimulus	Pass/Fail Criteria	Notes
1G	• Test packet stream from Paragon-neo. • ESMC stream from Paragon-neo (if desired). • Superimpose jitter to G.8262.1 9.3.1 Figure 6/ G.8262 9.2 Figure 9 (same values).	For all Jitter values presented: • The eEEC/EEC does not drop packets or change ESMC status (dependent on test method used). • The eEEC/EEC does not Error/Alarm during the test. • The eEEC/EEC does not go into Holdover.	• Allow settling time at each measurement point. • Either as pass/fail with presented jitter values at the mask, or a margin test with jitter values above mask.
10G lanes (100GbE SR10, 40GbE, 10GbE)	• Test packet stream from Paragon-neo. • ESMC stream from Paragon-neo (if desired). • Superimpose jitter to G.8262 9.2 Figure 10.	For all Jitter values presented: • The eEEC/EEC does not drop packets or change ESMC status (dependent on test method used). • The eEEC/EEC does not Error/Alarm during the test. • The eEEC/EEC does not go into Holdover.	• Input Stimulus for eEEC is for further study in G.8262.1 – for compatibility with EEC, using values as per G.8262 9.2 Figure 10 is recommended. • Allow settling time at each measurement point. • Either as pass/fail with presented jitter values at the mask, or a margin test with jitter values above mask.
25G lanes (100GbE SR/LR4, 25GbE SR/LR)	• Test packet stream from Paragon-neo. • ESMC stream from Paragon-neo (if desired). • Superimpose jitter to G.8262 9.2 Table 13.	For all Jitter values presented: • The eEEC/EEC does not drop packets or change ESMC status (dependent on test method used). • The eEEC/EEC does not Error/Alarm during the test. • The eEEC/EEC does not go into Holdover.	• Input Stimulus for eEEC is for further study in G.8262.1 – for compatibility with EEC, using values as per G.8262 9.2 Table 13 is recommended. • Allow settling time at each measurement point. • Either as pass/fail with presented jitter values at the mask, or a margin test with jitter values above mask.

Measurement Setup

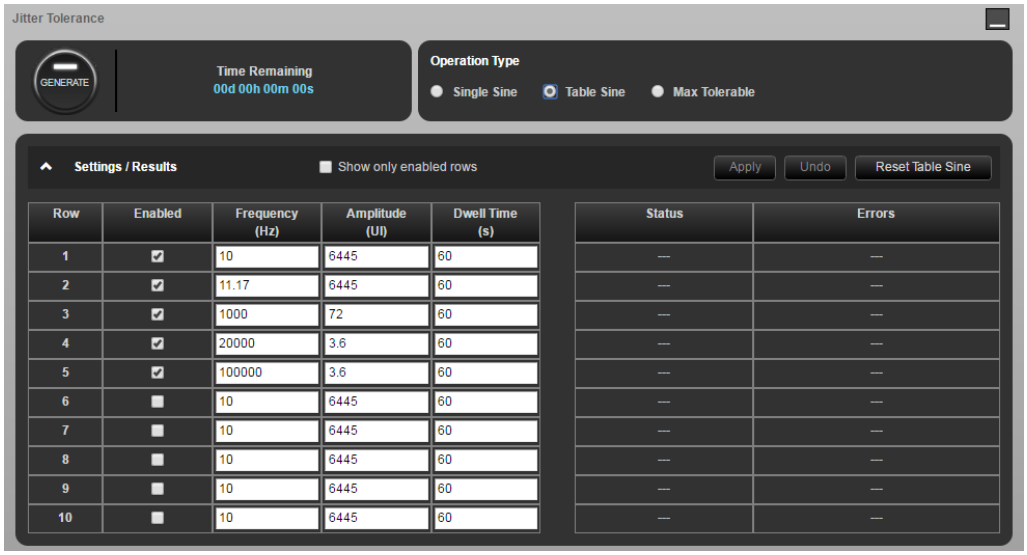
1. Connect the eEEC/EEC to Paragon-neo as shown in the diagram at the beginning of this section.
2. From the **Presets** panel, select **SyncE Jitter**.

3. Select the 

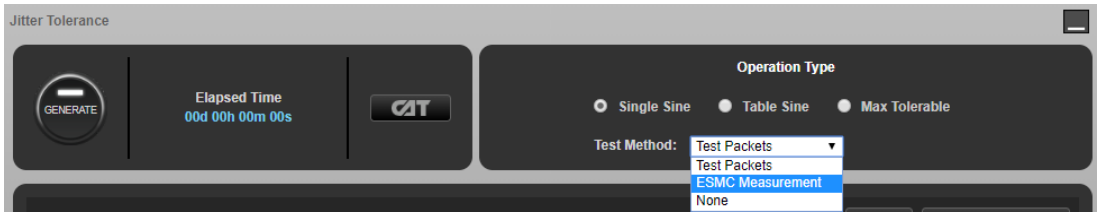
button on the Paragon-neo GUI, and then on the Jitter Tolerance panel, select **Table Sine**.

4. In the Jitter Tolerance Table, enter the **Frequency, Amplitude** and **Dwell Time** for each row. The GUI initially shows the standards-compliant default settings for the selected interface. These defaults may be restored by selecting the **Reset table sine** button.

   Any changes made to the table entries will be highlighted yellow. To apply these changes, click **Apply.**



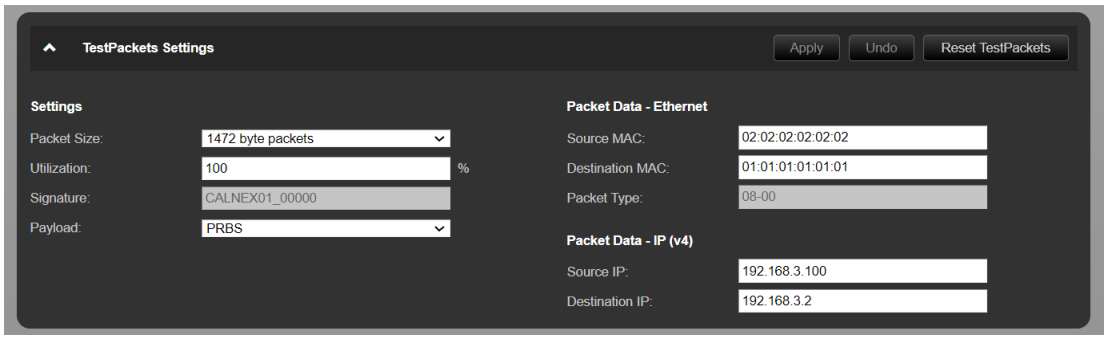
5. It is possible to measure the received ESMC messages from a device, monitoring for state changes to determine pass/fail directly from the Paragon-neo. You can switch between the **Test Packets** and **ESMC Measurement** method from the **Test Method** drop-down selector in the **Jitter Tolerance** app.



6. Note that it is also possible to select **None** to switch off other test methods and instead monitor the DUT directly for alarms, etc.

7. If **ESMC Measurement** is selected, then once **Generate** has been pressed to start the Tolerance test, ESMC measurement will automatically run on Port 1 (which will be the connection back to Paragon-neo from the DUT during Jitter testing), and status can be viewed real-time by selecting **CAT.** It is then possible to view any state changes, indicating for example that input jitter has not been tolerated and the DUT has switched to an alternate reference source.

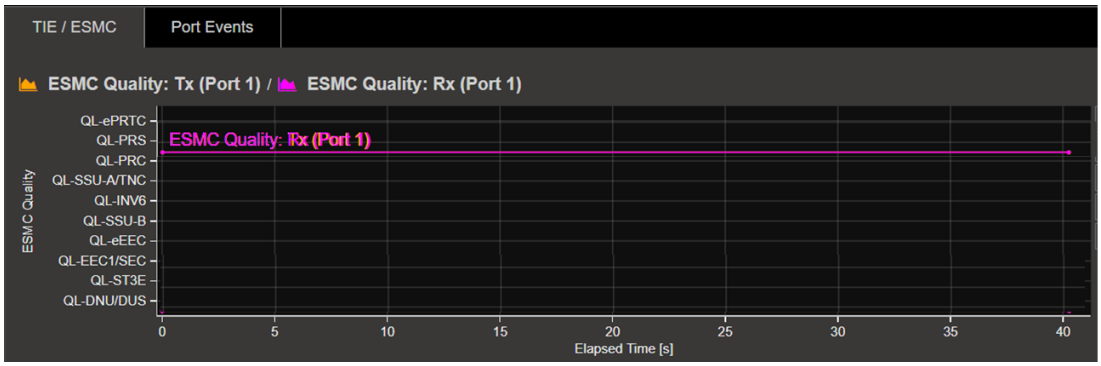
8. If desired, select **Test Packet Settings** and configure the test packets generated by the Paragon-neo to meet your requirements. There are selections for Packet Size, Utilization and Payload plus Source and Destination MAC, and IP addresses.



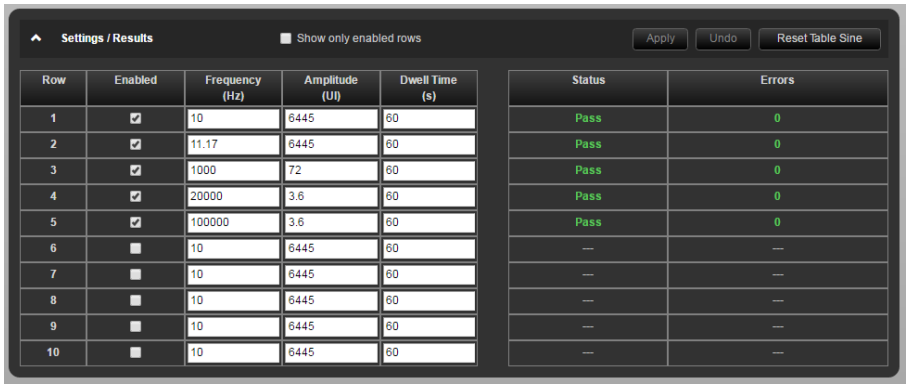
9. To start a Jitter Tolerance measurement, select **Generate**. The Paragon-neo will now generate Jitter at the selected Jitter Frequency and Amplitude. The test will cycle through all configured settings and stop automatically.

   To manually stop the Jitter Tolerance measurement, select the **Stop** button.

10. If using the ESMC method (recommended), launch **CAT** to monitor for ESMC state changes indicating that the DUT has lost lock. It is important to verify that the eEEC/EEC does not Error/Alarm or go into Holdover during the test for all jitter values presented.

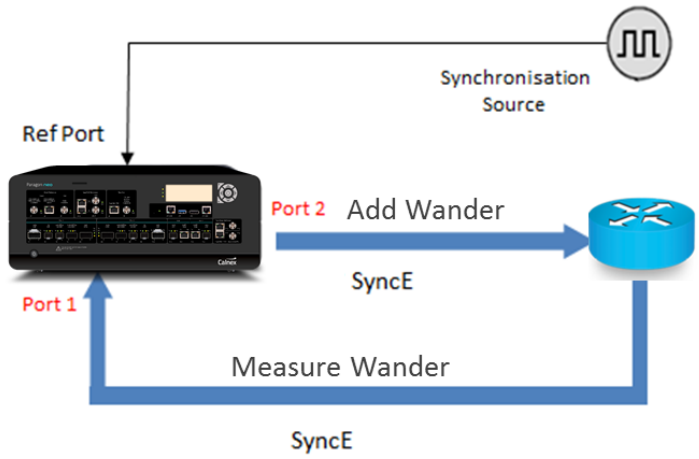


11. If using the test packets method, the result will indicate if any dropped or out of sequence packets were detected, with a **Pass** or **Fail** result appearing for each enabled Frequency/Amplitude pairing after that pair has been tested.



Row	Enabled	Frequency (Hz)	Amplitude (UI)	Dwell Time (s)	Status	Errors
1	☑	10	6445	60	Pass	0
2	☑	11.17	6445	60	Pass	0
3	☑	1000	72	60	Pass	0
4	☑	20000	3.6	60	Pass	0
5	☑	100000	3.6	60	Pass	0
6	☐	10	6445	60	—	—
7	☐	10	6445	60	—	—
8	☐	10	6445	60	—	—
9	☐	10	6445	60	—	—
10	☐	10	6445	60	—	—

10. Wander (Noise) Transfer – G.8262.1/G.8262 Section 10



	Input Stimulus	Pass/Fail Criteria	Notes
eEEC	Tones.	In the passband (1Hz-3Hz), the phase gain of the eEEC should be smaller than 0.2dB (2.3%).	There is no definition of the input stimulus to be used in G.8262 or G.8262.1. it is suggested that the frequency values are carefully chosen to avoid aliasing effects, and provide coverage below, in and above the passband, with testing including assessment of filter roll-off characteristics – Calnex provides recommended input values and test masks directly in Paragon-neo GUI.
EEC Option 1	Tones.	In the passband (1Hz-10Hz), phase gain of the EEC should be smaller than 0.2dB (2.3%).	
EEC Option 2	TDEV Wander Table 10, Figure 8.	Measure EEC output against TDEV Pass/Fail masks shown in G.8262 Section 10.2 Table 14, Figure 11.	If your instrument does not feature MTIE/TDEV Wander Generation, then you can use the Table Sine function below.
	Tones.	Max bandwidth 0.1Hz, no minimum bandwidth specified. First order filter with 20dB/decade is assumed.	There is no definition in G.8262 of the input stimulus for an Option 2 clock using tones - Calnex provides recommended input values carefully chosen to avoid aliasing effects and provide coverage and test masks directly in Paragon-neo GUI to test attenuation and filter roll-off characteristics. These are based on the G.824 network limit for 1.544 kbit/s (Option 2 clocks) to test noise transfer using maximum allowable input amplitudes for that network type.

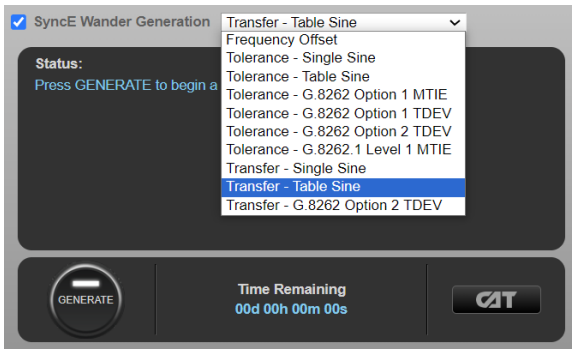
Measurement Setup

1. Connect the eEEC/EEC to Paragon-neo as shown in the diagram at the beginning of this section.
2. Set up the Paragon-neo as described in Section 3, including setting up ESMC with the following settings if using ESMC to monitor if the eEEC/EEC is switching clock references or going into holdover:

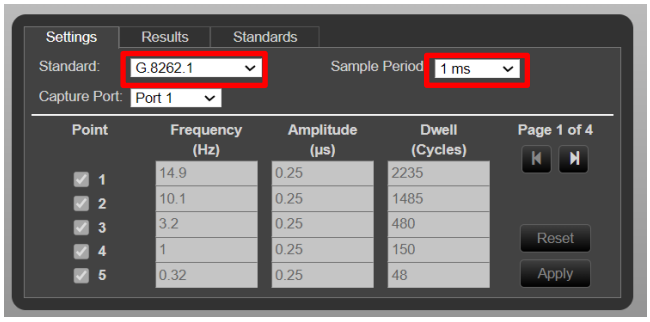
Clock Type	Network Option	SSM Code
eEEC	Option 1	QL-PRC
EEC Option 1	Option 1	QL-PRC
EEC Option 2	Option 2	QL-PRS

Measurement Process – eEEC

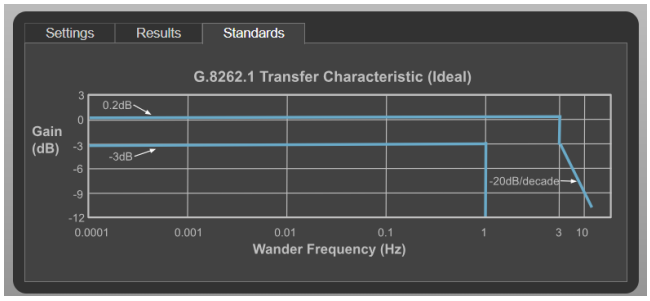
1. Tick the **Wander Generation** check box on the Paragon-neo GUI. Note, you may have to stop any running measurements and then tick the Wander Generation selection.
2. Select **Transfer – Table Sine** from the drop-down menu.



3. In **Settings**, select **Standard: > G.8262.1** to populate the stimulus table (and allow appropriate limits to be applied to capture data).
4. Set the **Sample Period** to 1 millisecond (1 kHz)



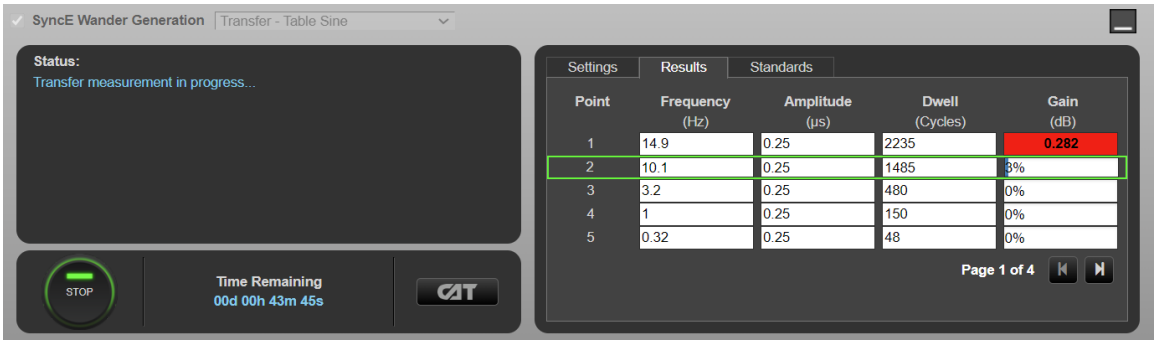
5. The **Standards** tab shows the gain mask.



6. Click the 

button to start the test. The duration is 46m 30s.

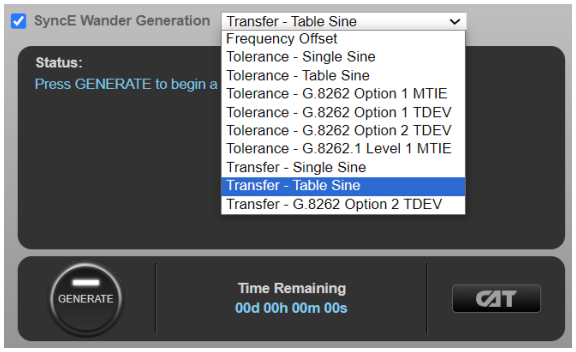
7. The Paragon-neo will show the estimated time remaining at the bottom of the screen and will indicate the progress as it runs through the test, with pass/fail indication for each test point once complete.



8. Launching **CAT** will provide a gain plot, and G.8262.1 limits can be applied, for visualization of DUT filter characteristics.

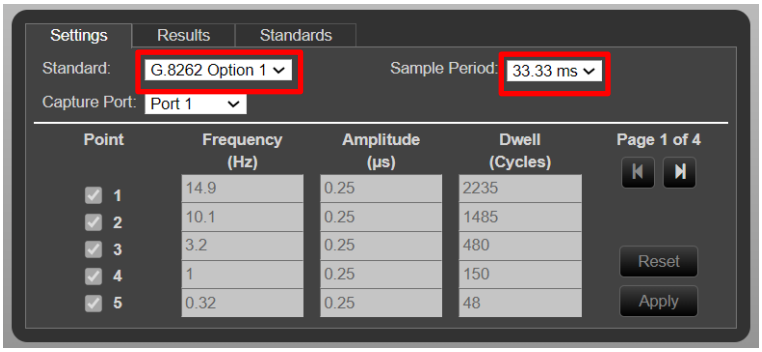
Measurement Process – EEC Option 1

1. Tick the **Wander Generation** check box on the Paragon-neo GUI. Note, you may have to stop any running measurements and then tick the Wander Generation selection.
2. Select **Transfer – Table Sine** from the drop-down menu.



3. In **Settings**, select **Standard: > G.8262 Option 1** to populate the stimulus table (and allow appropriate limits to be applied to capture data).

   Set the **Sample Period** to 33.33 milliseconds (30 Hz).

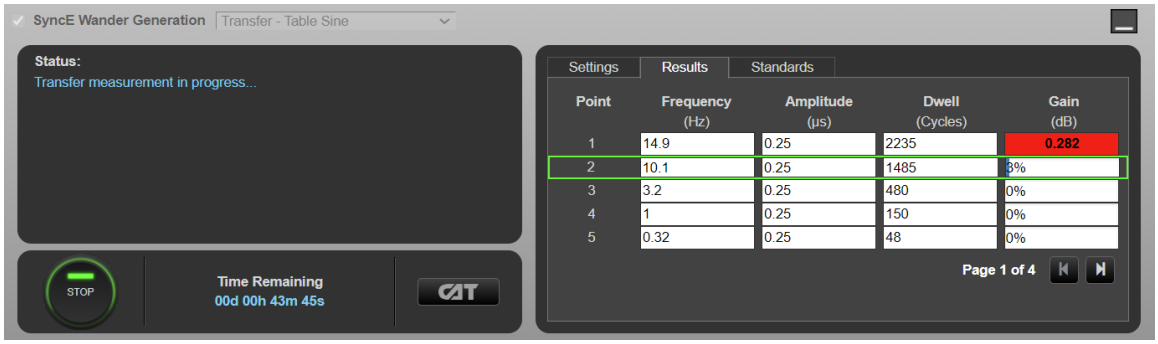


4. The **Standards** tab shows the gain mask.

5. Click the 

button to start the test. The duration is 46m 30s.

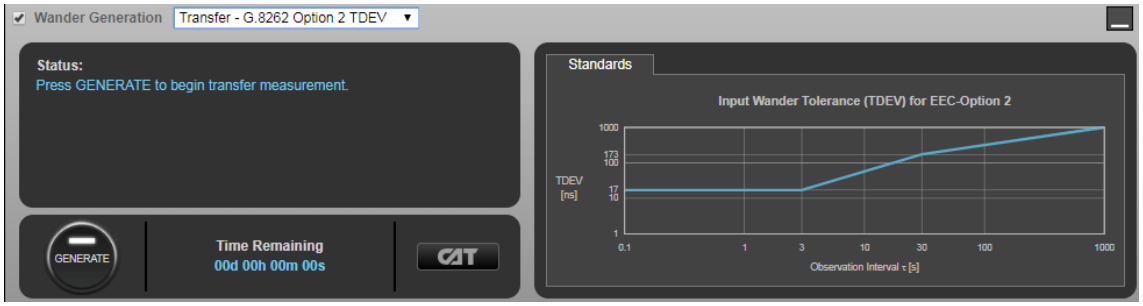
6. The Paragon-neo will show the estimated time remaining at the bottom of the screen and will indicate the progress as it runs through the test with pass/fail indication for each test point once complete.



7. Launching **CAT** will provide a gain plot, and G.8262 EEC Opt 1 limits can be applied, for visualization of DUT filter characteristics.

Measurement Process - EEC Option 2 TDEV

1. Select **Transfer – G.8262 Option 2 TDEV** from the drop-down menu. This will display G.8262 TDEV Wander Tolerance mask for EEC-Option 2.



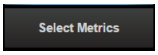
2. Click the 

button to start the test. Test duration is 3h 20m.

3. The estimated time to completion of the test is shown at the bottom of the wander generation app.

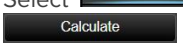
4. At any time during the test, it is possible to view the TDEV plot. To display the TDEV results, select 

to open CAT in a separate browser tab. The plots will show the captured TIE data.

5. To display the TDEV graph, press 

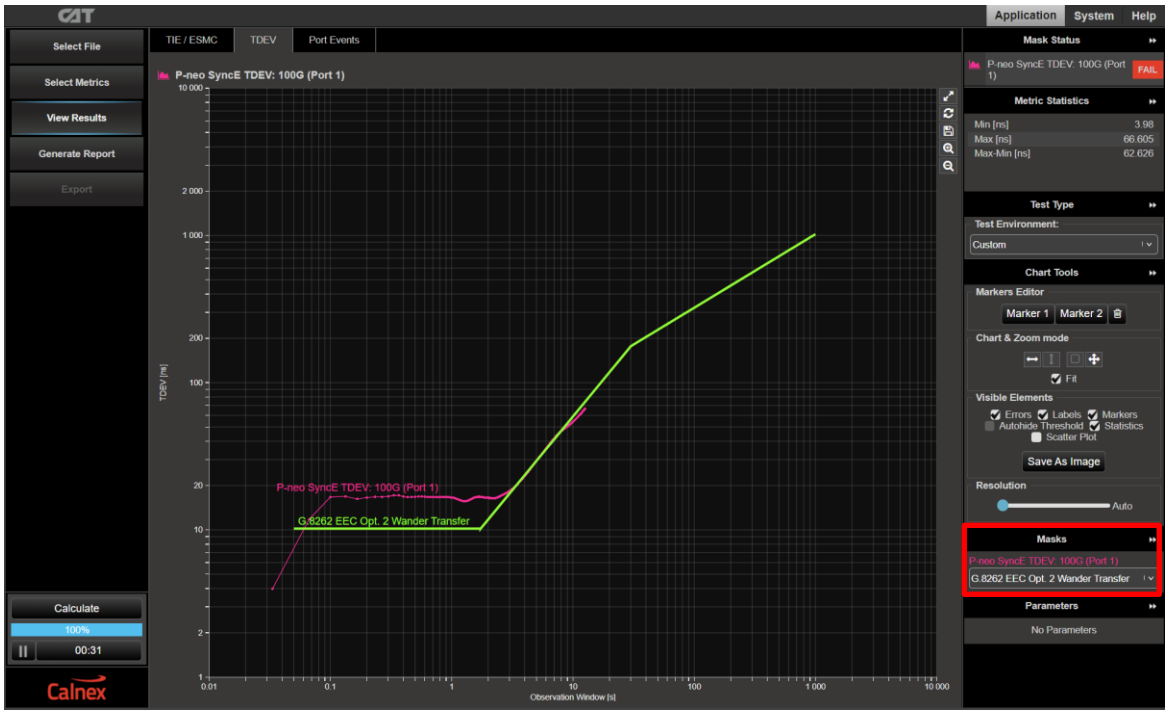
then check the TDEV tick box.

6. Select 

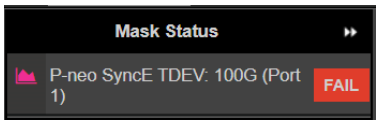
on the left-hand side of the graph, select **TDEV** from the tabs at the top, then click the 

button.

7. The TDEV results can be reviewed against the G.8262 masks by choosing the **G.8262 Wander Transfer** mask from the Metric Mask pull down menu under **Masks** at the right of the graph.

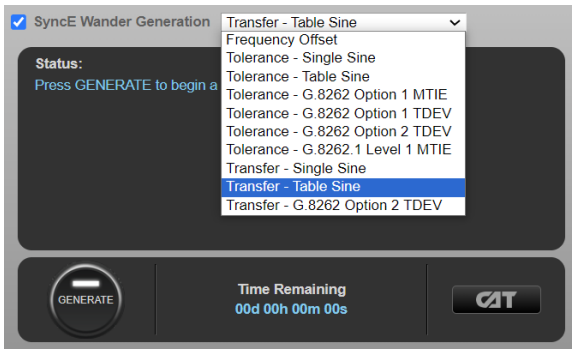


8. Pass/Fail indication against the mask is shown to the right under Mask Status Service with green highlight for a “Pass” and red highlight for a “Fail”.

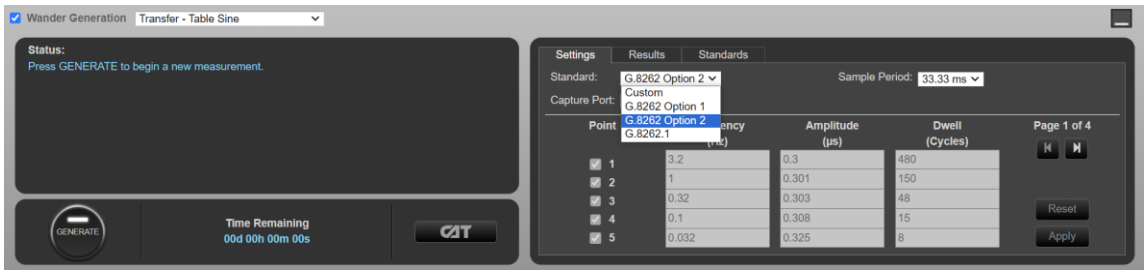


Measurement Process - EEC Option 2 Using Tones

1. Tick the **Wander Generation** check box on the Paragon-neo GUI. Note that you may have to stop any running measurements and then tick the Wander Generation selection.
2. Select **Transfer – Table Sine** from the drop-down menu.

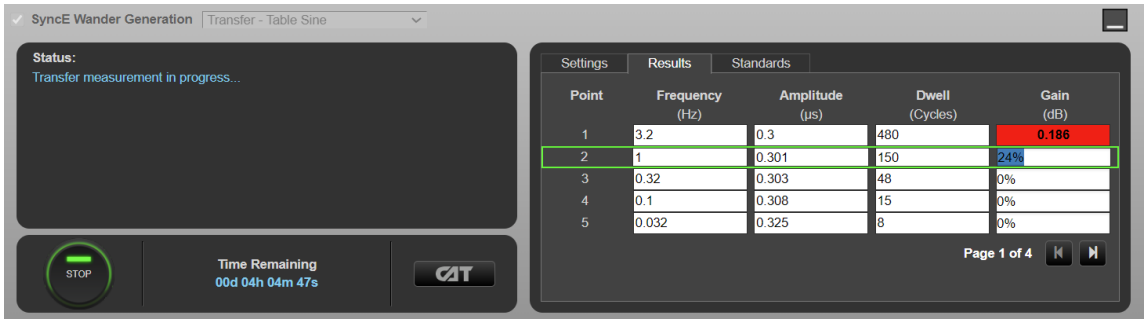


3. In **Settings**, select **Standard: > G.8262 Option 2** to populate the stimulus table (and allow appropriate limits to be applied to capture data):

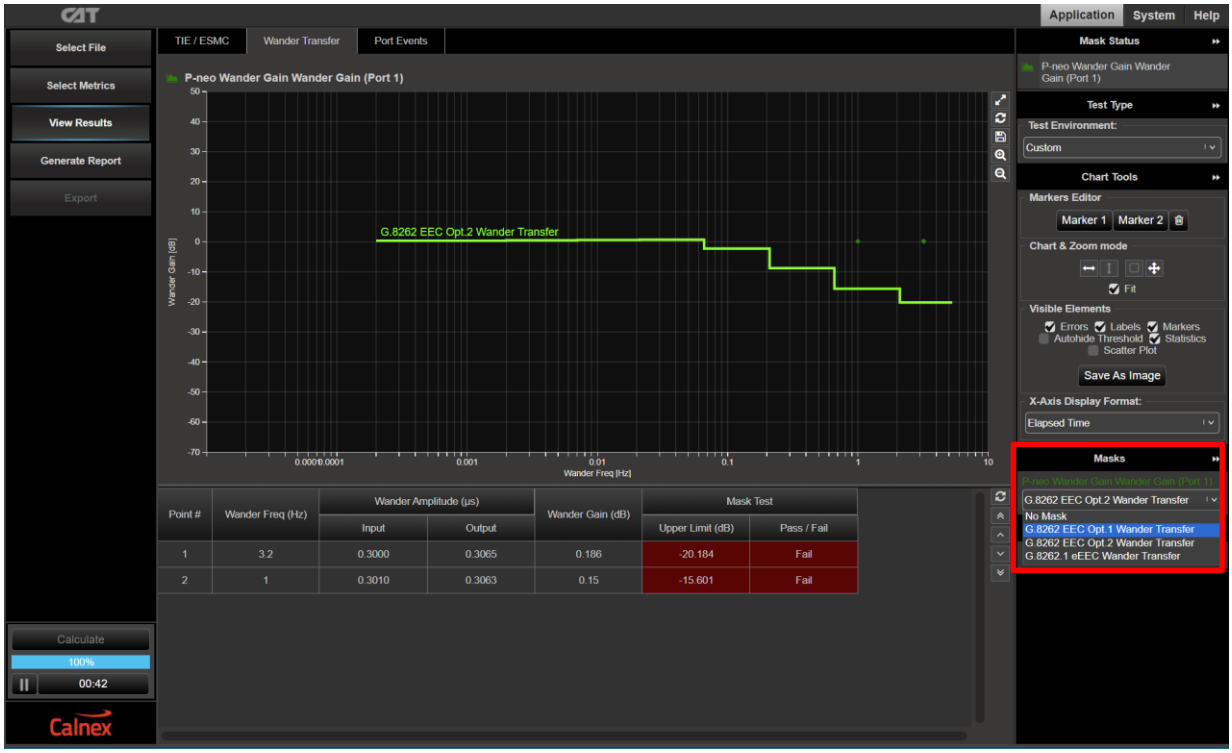


4. Click the 

button to start the test. The test duration is 4h 10m.
5. The Paragon-neo will show the estimated time remaining at the bottom of the screen and will indicate the progress as it runs through the test, with pass/fail indication for each test point once complete.



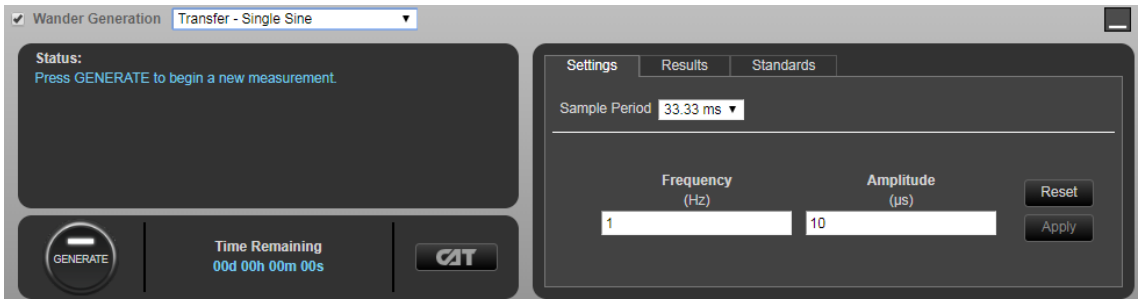
6. Launching **CAT** will provide a gain plot, and G.8262 EEC Opt 2 limits can be applied, for visualization of DUT filter characteristics. The G.8262 EEC Option 2 filter has no lower gain limit.



Optional: Paragon-neo single frequency test

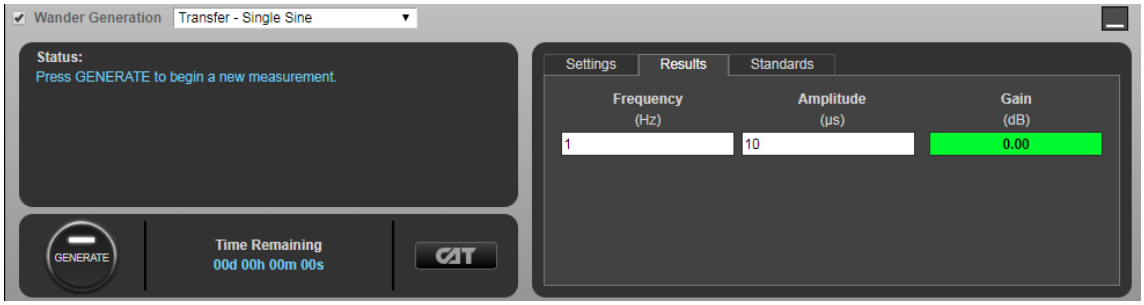
This capability can be used for fault finding issues that have occurred at specific frequencies.

1. Select **Transfer – Single Sine** from the drop-down menu.



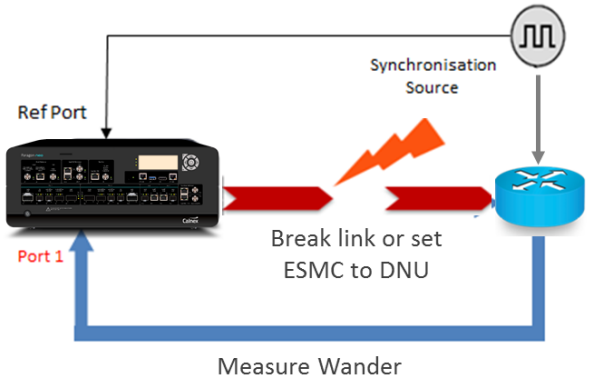
2. Enter the frequency and amplitude of the wander to be generated.
3. Click the 

button to start the test.
4. The Paragon-neo will show the estimated completion time at the bottom of the screen and will indicate the progress as it runs through the test, displaying the measured Gain (dB) value and a Green (Pass)/Red (Fail) indication vs. 2dB on the last (Gain) column.



11. Short Term Phase Transient Response – G.8262.1/G.8262 Section 11.1

Short term phase transient response



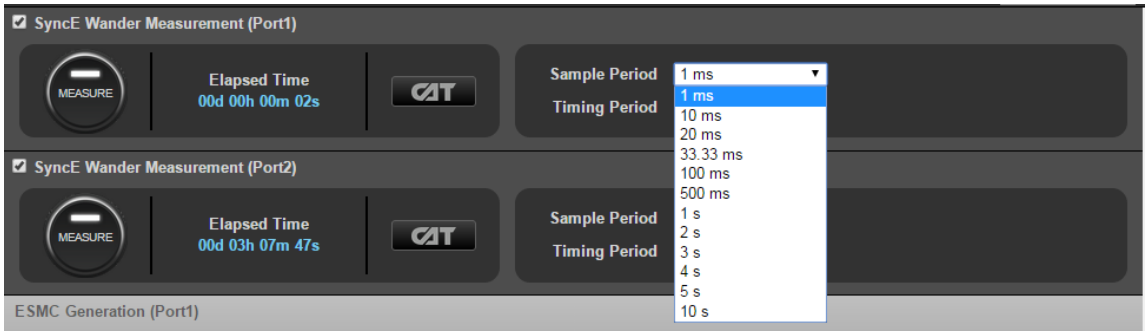
	Input Stimulus	Pass/Fail Criteria	Notes
eEEC	eEEC input reference is lost for up to 15 seconds and a second reference input signal, traceable to the same reference clock, is available simultaneously.	Maximum phase transient at the output due to reference switching to meet mask in G.8262.1 Figure 7.	To emulate the loss of the link either: Change ESMC QL=DNU (Option 1 Network) or Remove the cable between Port 2 and eEEC.
EEC Option 1	EEC input reference is lost for up to 15 seconds and a second reference input signal, traceable to the same reference clock, is available simultaneously.	Maximum phase transient at the output due to reference switching to meet mask in G.8262 Figure 12.	To emulate the loss of the link either: Change ESMC QL=DNU (Option 1 Network) or Remove the cable between Port 2 and EEC.
EEC Option 2	EEC input reference is lost for up to 15 seconds and a second reference input signal, traceable to the same reference clock, is available simultaneously.	EEC output should meet MTIE mask defined by Table 15, Figure 14 in Section 11.4.2 of G.8262.	To emulate the loss of the link either: Change ESMC QL=DUS (Option 2 Network) or Remove the cable between Port 2 and EEC.

Measurement Setup

1. Connect the eEEC/EEC to Paragon-neo as shown in the diagram at the beginning of this section.
2. Set up the Paragon-neo as described in Section 3, including setting up ESMC with the following settings if using ESMC to monitor if the eEEC/EEC is switching clock references or going into holdover:

Clock Type	Network Option	SSM Code
eEEC	Option 1	QL-PRC
EEC Option 1	Option 1	QL-PRC
EEC Option 2	Option 2	QL-PRS

3. For **SyncE Wander Measurement (Port 1),** open the **Sample Period** drop down menu and select a **1ms** sample period.



Measurement Process

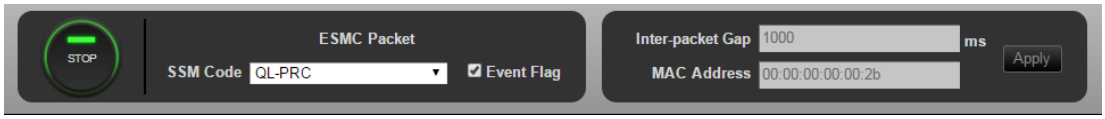
There are two methods for determining Phase Transient Response with the Paragon-neo:

- Use ESMC Generation (if supported by the DUT).
- Remove the link between Port 2 on the Paragon-neo and the eEEC/EEC input port.

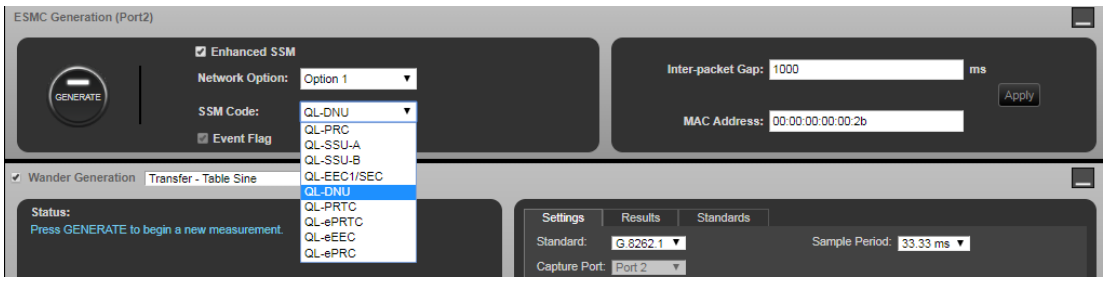
1. Select the 

button on SyncE Wander Measurement (Port 1) to start the measurement.
2. Launch **CAT** to monitor results (see below).
3. Use one of the two methods described to create a disruption for a maximum of 15 seconds.
4. If using the Ethernet cable removal method, disconnect the cable between Port 2 and the eEEC/EEC, then reconnect after 15 seconds.
5. If using the ESMC method:
   a) Refer to the ESMC Generation track for **Port 2** as shown below.
   b) Ensure SSM code is already set to e.g. **QL–PRC** (Option 1 Network) or **QL-PRS** (Option 2 Network) and ensure the 

button is already selected.



   c) In the SSM Code drop down menu select **QL–DNU** (Option 1 Network) or **QL-DUS** (Option 2 Network).



6. To stop the measurement, press the 

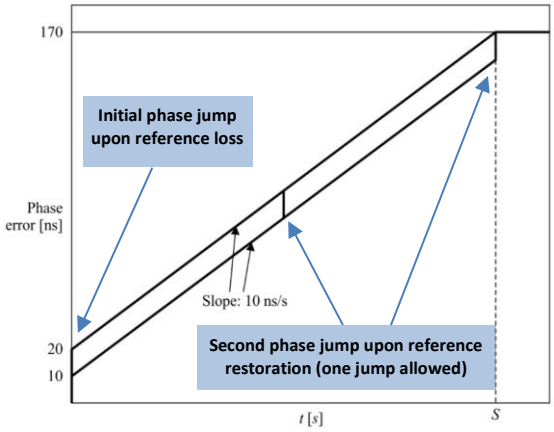
button on SyncE Wander Measurement (Port 1).

Measuring Results

Note that the method of evaluating the capture for phase transient response is dependent on whether eEEC, EEC Option 1 or Option 2 is being evaluated.

eEEC

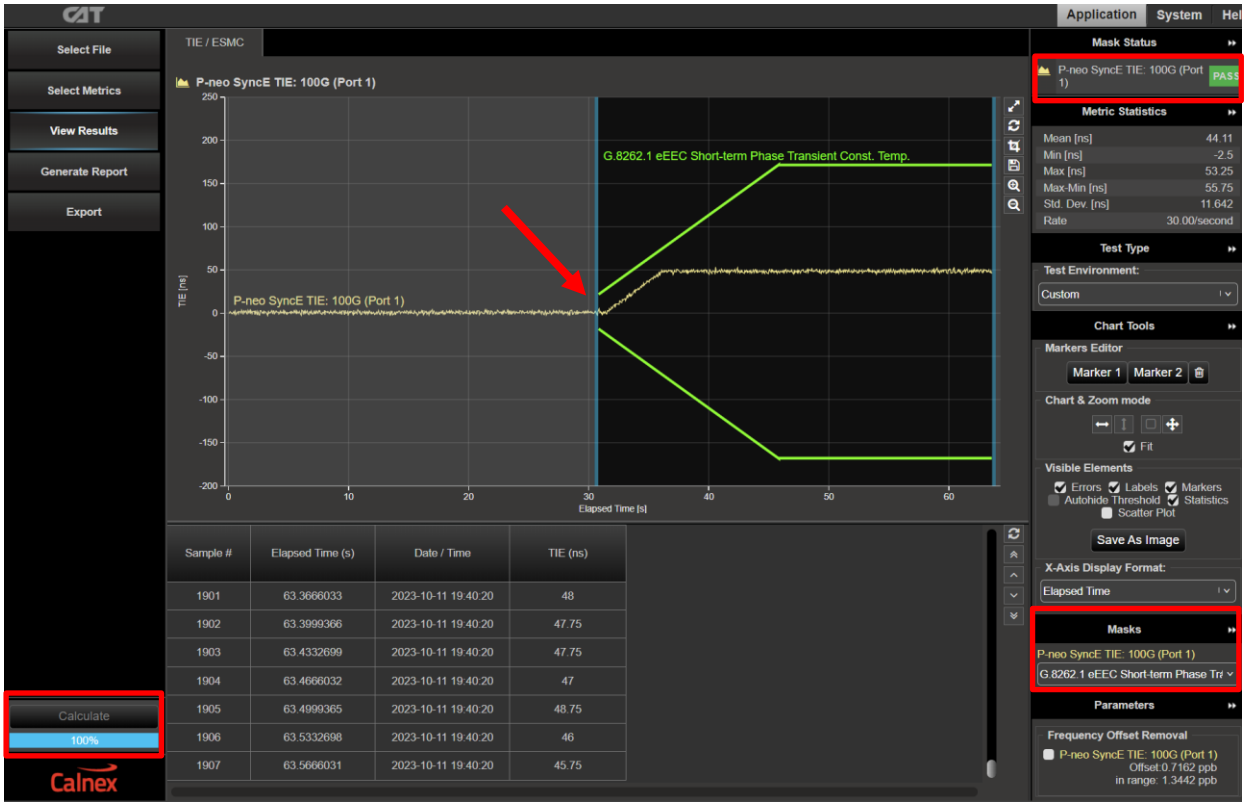
Monitor the output **TIE** graph in **CAT** over the duration (15s) of the test. While the device under test is acquiring the new reference, the output phase transient should be within the limits of Figure 6 of G.8262.1 (provided below).



In **CAT**, select the appropriate TIE mask from the drop-down menu on the right-hand side of the graph.

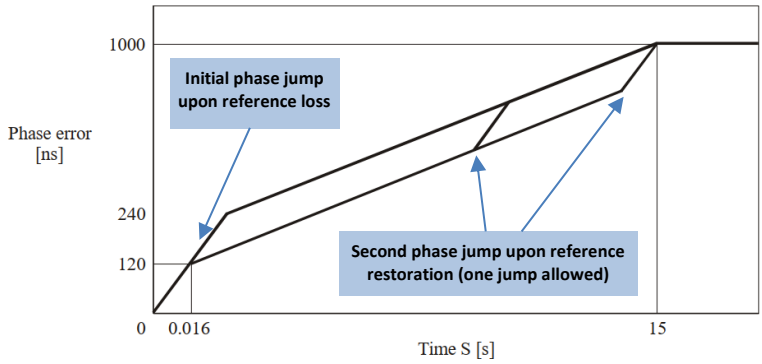
To ensure that the start of the mask is aligned with the start of the transient, left click and hold on the left side of the graph to use the drag function and move the **Data Analysis Range** from the left of the measurement data to the visible start of the transient.

Click the Calculate button to recalculate the metric. The mask status of **Pass** or **Fail** is indicated in the top right of the screen.



EEC Option 1

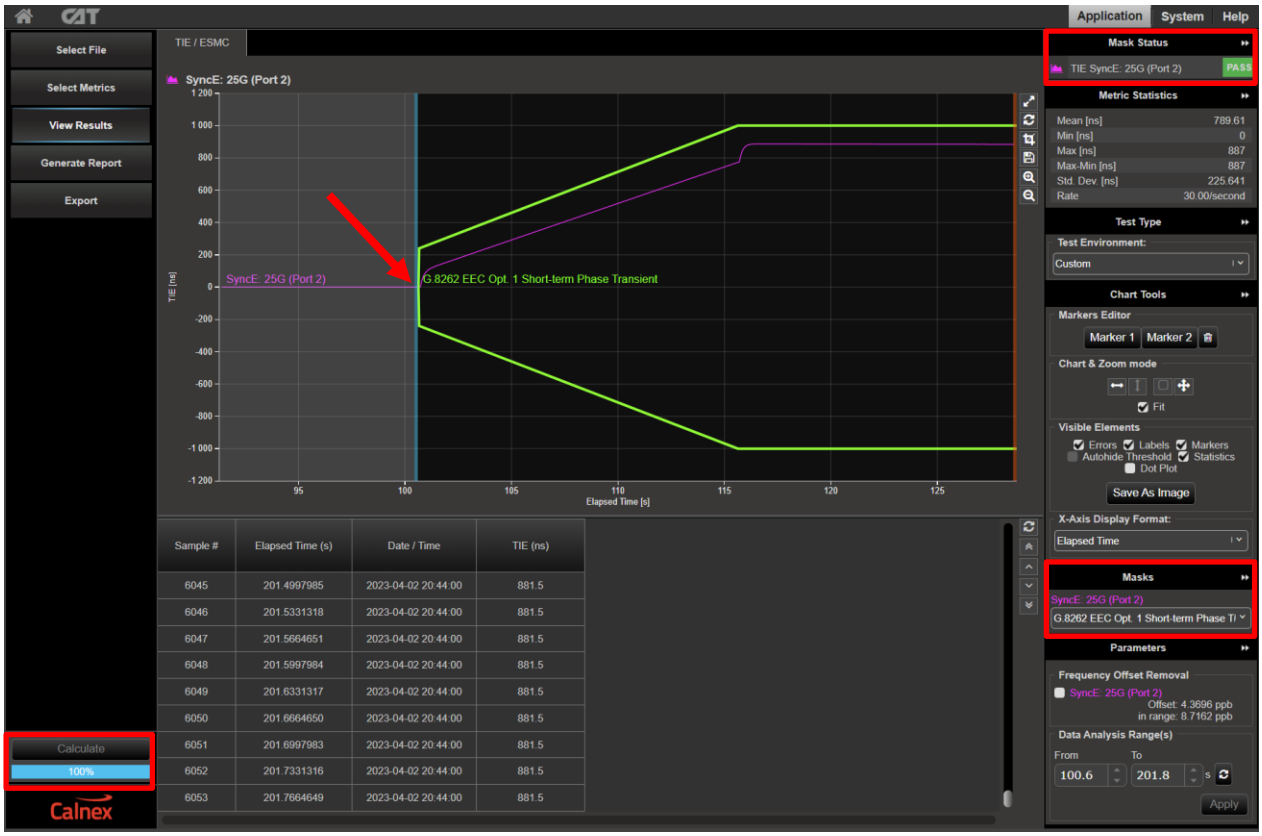
Monitor the output **TIE** graph in **CAT** over the duration (15s) of the test. While the device under test is acquiring the new reference, the output phase transient should be within the limits of Figure 12 of G.8262 (provided below).



In **CAT**, select the appropriate TIE mask from the drop-down menu on the right-hand side of the graph.

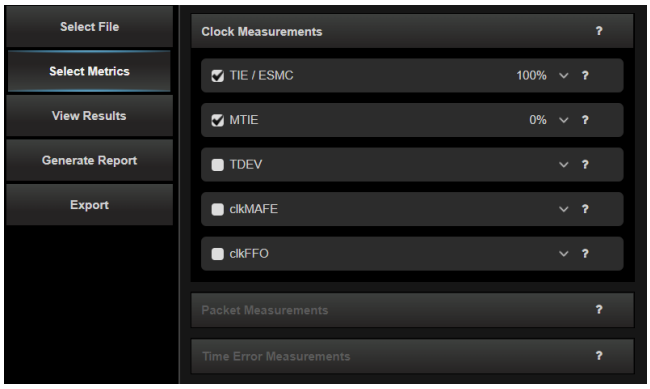
To ensure that the start of the mask is aligned with the start of the transient, left click and hold on the left side of the graph to use the drag function and move the **Data Analysis Range** from the left of the measurement data to the visible start of the transient.

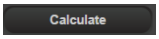
Click the Calculate button to recalculate the metric. The mask status of **Pass** or **Fail** is indicated in the top right of the screen.

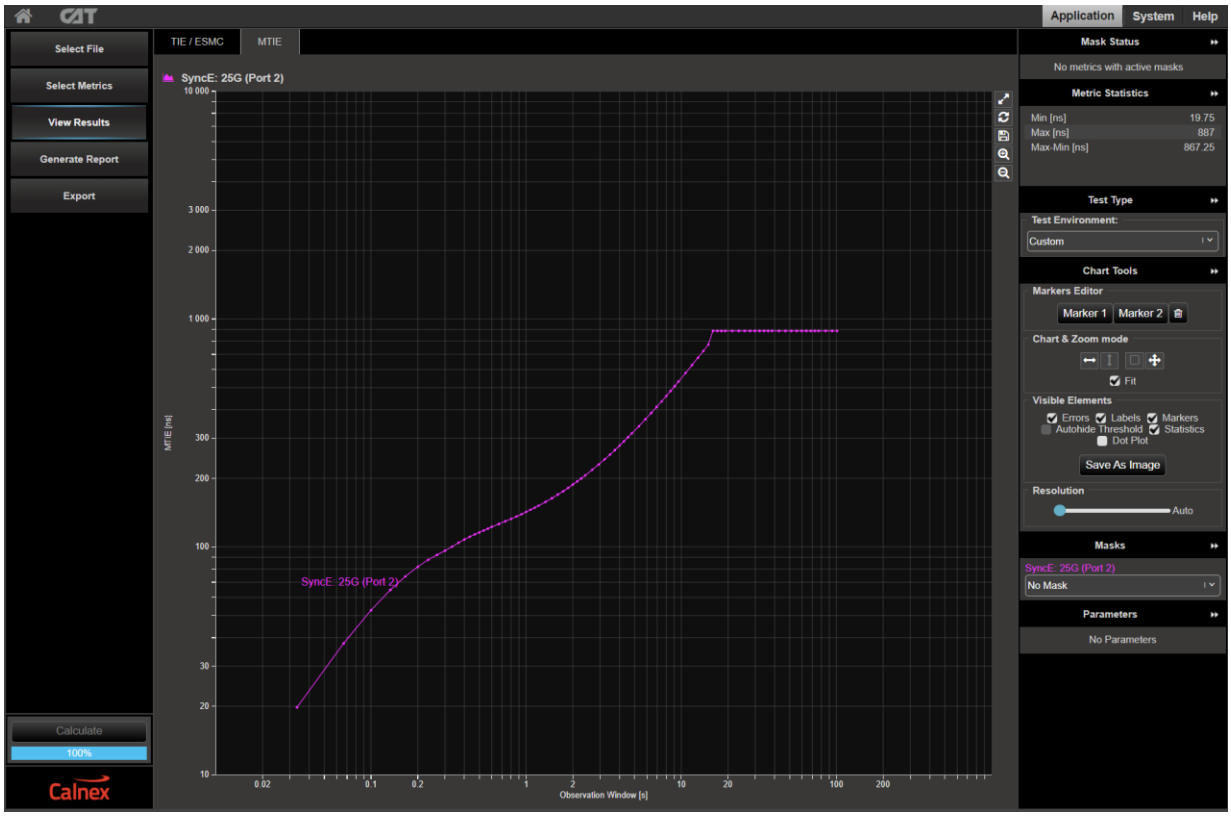


EEC Option 2

1. To view the output MTIE mask for EEC Option 2 **ONLY**, perform the following:
2. In CAT, choose **Select Metrics** and then tick the **MTIE** checkbox.



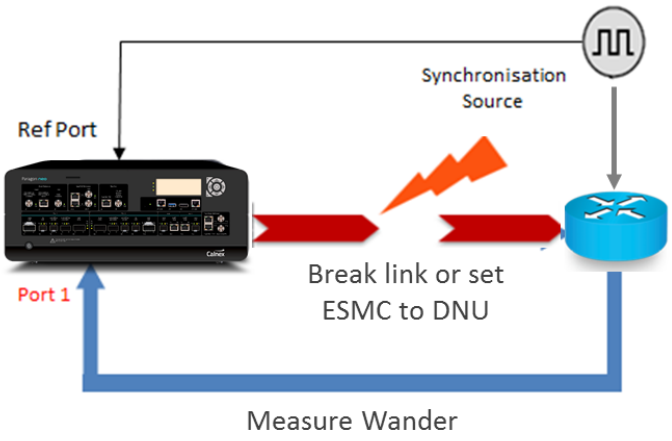
3. Select **View Results** then select the MTIE tab. Next, select the  button on the left of the window. This will display the MTIE metrics graph.



4. The MTIE analysis can be carried out against the G.8262 masks for Wander Transient which can be selected from the **Metric Mask** pull down selection at the bottom of the window.

   Pass/Fail indication is shown in the top right under **Mask Status** with green highlight for “Pass” and red for “Fail”.

12. Long-term Phase Transient Response (Holdover) G.8262.1/G.8262 Section 11.2



	Input Stimulus	Pass/Fail Criteria	Notes
eEEC	eEEC input reference is permanently lost or declared DNU.	Maximum phase transient and excursion at the output due to reference switching to meet mask in G.8262.1 Figure 8.	To emulate the loss of the link either: Change ESMC QL=DNU (Option 1 Network) or Remove the cable between Port 2 and eEEC Measure for 10,000 seconds (approx. 3hrs).
EEC Option 1	EEC input reference is permanently lost or declared DNU.	Maximum phase transient and excursion at the output due to reference switching to meet mask in G.8262 Figure 13.	To emulate the loss of the link either: Change ESMC QL=DNU (Option 1 Network) or Remove the cable between Port 2 and EEC Measure for 10,000 seconds (approx. 3hrs).
EEC Option 2	EEC input reference is permanently lost or declared DNU.	Maximum phase transient and excursion at the output due to reference switching to meet mask in G.8262 11.2.2 and Table 14, including 1st and 2nd derivatives of phase vs time.	To emulate the loss of the link either: Change ESMC QL=DNU (Option 2 Network) or Remove the cable between Port 2 and EEC Measure for 10,000 seconds (approx. 3hrs).

Measurement Setup and Process

1. Set the ESMC being generated on Port 2 of the Paragon-neo to e.g. **QL-PRC** (Option 1 Network) or **QL-PRS** (Option 2 Network). This will cause the DUT to lock to this signal and hence to the Synchronization Source.

2. After allowing the DUT to settle [leave for at least 900s (15 minutes) or as long as it takes the device to become fully synchronised] measure the wander on Port 1. The resulting graph should be flat and the Offset measurement at the bottom of the Wander TIE graph should indicate 0.000 ppm.

   The ESMC received from the DUT on Port 1 should match the input QL (e.g. **QL-PRC** or **QL-PRS**)

3. Restart the wander measurement and then set the ESMC on Port 2 to **DNU** (Option 1 Network, Do Not Use) or **QL-DUS** (Option 2 Network, Don't Use for Synchronization).

   This should cause the DUT to search for an alternative external clock signal to lock to. As there are no other external signals the DUT will use its internal clock. The ESMC messages on Port 1 should reflect this change with the appropriate Quality Level e.g. EEC1.

4. The **TIE** graph should show the SyncE signal from the DUT start to drift off. Leave the capture running for a minimum of 10,000 seconds (approx. 3 hours) then stop the measurement.

   It should be noted that there is no maximum timeframe that this specification applies so there is no maximum measurement time. The CAT mask will be applied for the whole test, regardless of duration.

   Monitor the output TIE graph via CAT throughout, or at the end of, the test.

   The output TIE should be within the limits shown above for the chosen device type. Select the appropriate TIE mask from the drop-down menu on the right-hand side of the graph. To ensure that the start of the mask is aligned with the start of the transient, left click and hold on the left side of the graph to use the drag function and move the data analysis range from the left of the measurement data to the visible start of the transient.

   Pass/Fail indication against the masks is shown to the right under Mask Status Service with green highlight for a "**Pass**" and red highlight for a "**Fail**"

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