TEST GUIDE

CX5026

Testing EECs as per ITU-T G.8262 using Paragon-100G

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

This Test Guide shows how the Paragon-100G can be used to perform the tests specified in the ITU-T G.8262 standard for proving SyncE Jitter and Wander performance at rates up to 100GbE. The tests include measurement of jitter generation, jitter tolerance, noise generation, noise tolerance and transfer, phase transient response and holdover performance. These are compulsory tests for SyncE equipment or systems.

Contents

1. Hardware and Software Required 3
2. Connecting an EEC to the Paragon-100G 4
3. How to Configure the Paragon-100G for ALL G.8262 Wander Tests 6
4. Measuring Frequency Accuracy – G.8262 Section 6 10
5. Pull-in, Hold-in and Pull-out ranges – G.8262 Section 7 12
6. Wander (Noise) Generation – G.8262 Section 8 15
7. Jitter Generation – G.8262 Section 8.3 18
8. Wander (Noise) Tolerance – G.8262 Section 9 20
9. Wander (Noise) Transfer – G.8262 Section 10 26
10. Jitter Tolerance – G.8262 Section 9.2 33
11. Phase Transient Response – G.8262 Section 11 36
12. Appendix 1 - G.8262; Practical Interpretation Guidance 44

1. Hardware and Software Required

Paragon-100G

Option 001 100GbE interface support (if the Device-Under-Test (DUT) has 100G interfaces)
Option 002 40GbE interface support (if the DUT has 40G interfaces)
Option 003 25GbE interface support (if the DUT has 25G interfaces)

Option 213 SyncE wander and ESMC
Option 223 G.8262 MTIE and TDEV wander generation
Option 208 G.2826 SyncE jitter

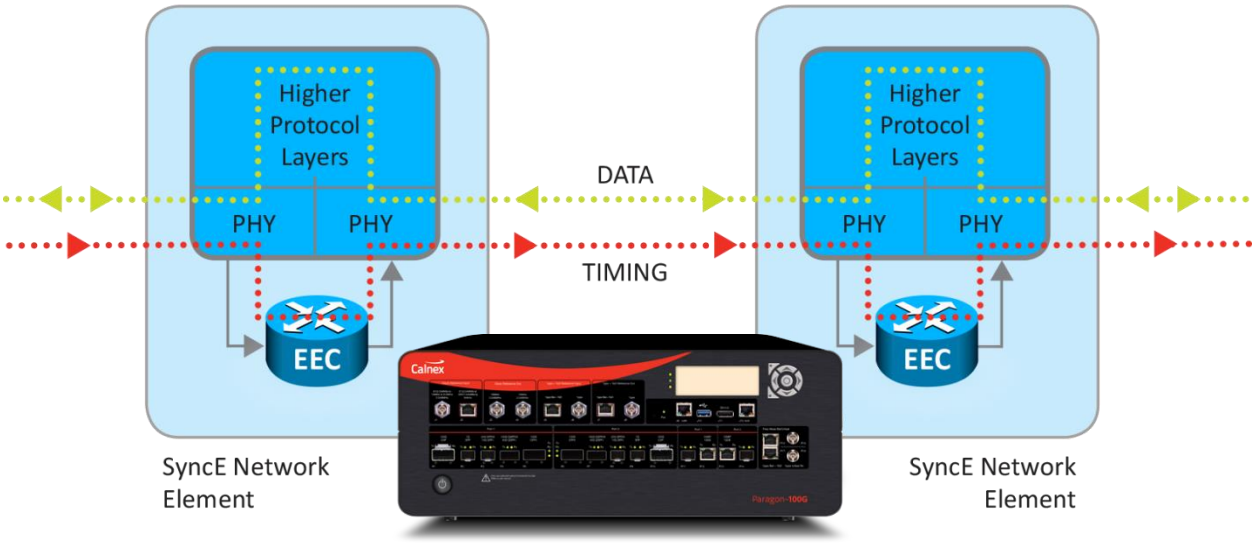
Software version: 60.05.03.xx and later

Accessories

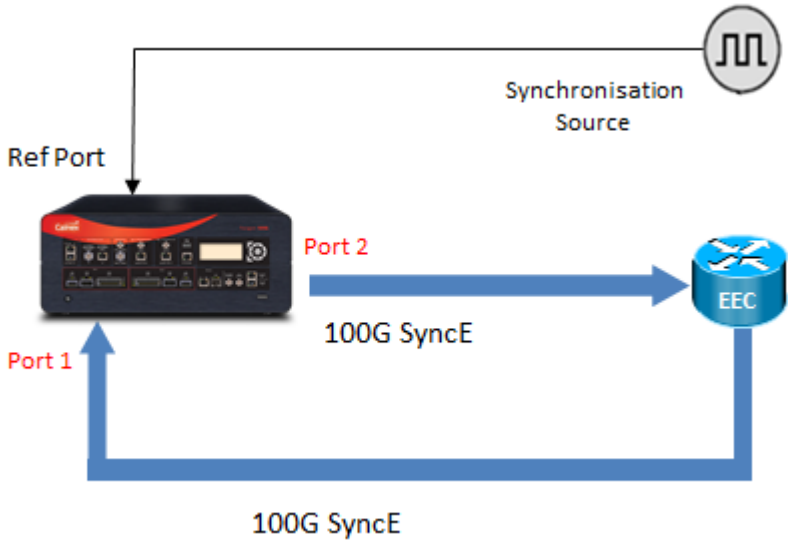
- Optical Transceivers as required
- Cables as required

Frequency Reference Source

Option 132 GPS/Rubidium Clock (optional)

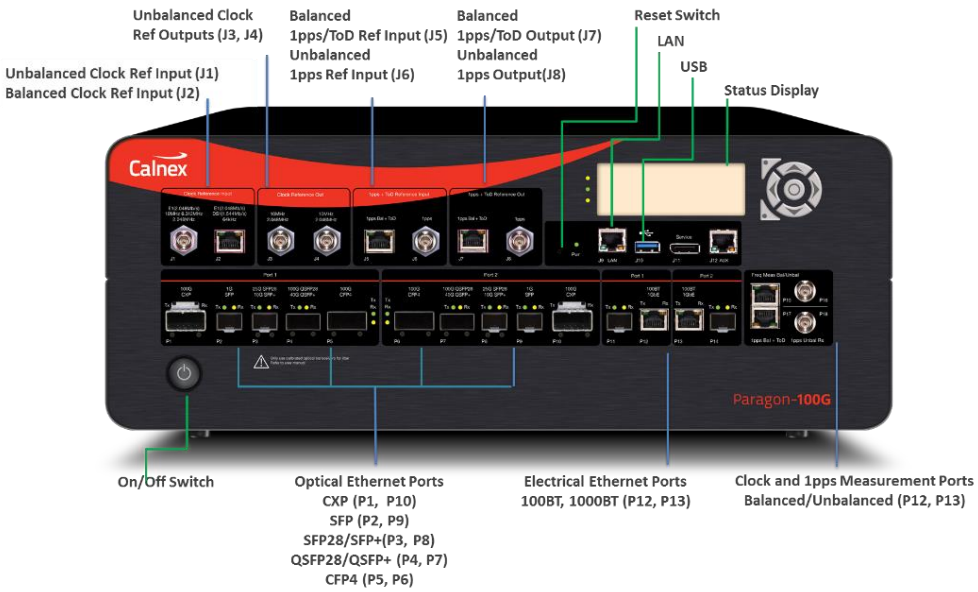


2. Connecting an EEC to the Paragon-100G



The front panel of the Paragon-100G provides the following interfaces for testing:

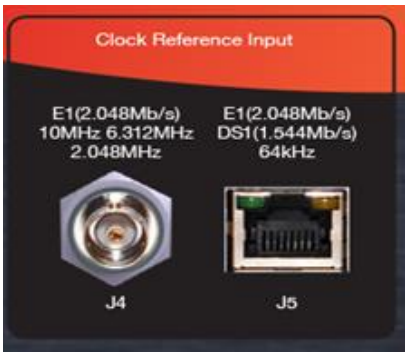
- 100GbE CXP (SR10) – *with option 001 fitted; SR10 optical modules not supplied*
- 100GbE (LR4) – *with option 001 fitted; LR4 optical modules for Jitter units must be ordered and supplied with unit as they are calibrated for accurate jitter performance*
- 40GbE QSFP+ – *with option 002 fitted; QSFP+ optical modules not supplied*
- 25GbE SFP28 – *with option 003 fitted*



Paragon-100G Front Panel Connections

The Paragon-100G accepts the following reference clocks which should be applied to one of the Reference Inputs on front panel (shown in the above Paragon-100G Front Panel Connections):

- 2.048MHz (J4 unbalanced)
- 10MHz (J4 unbalanced)
- E1 (2.048Mb/s) (J4 unbalanced or J5 balanced)
- DS1 (T1) (1.544Mb/s) (J5 balanced)
- 6.312MHz (J4 unbalanced)
- 64kHz (J5 balanced)



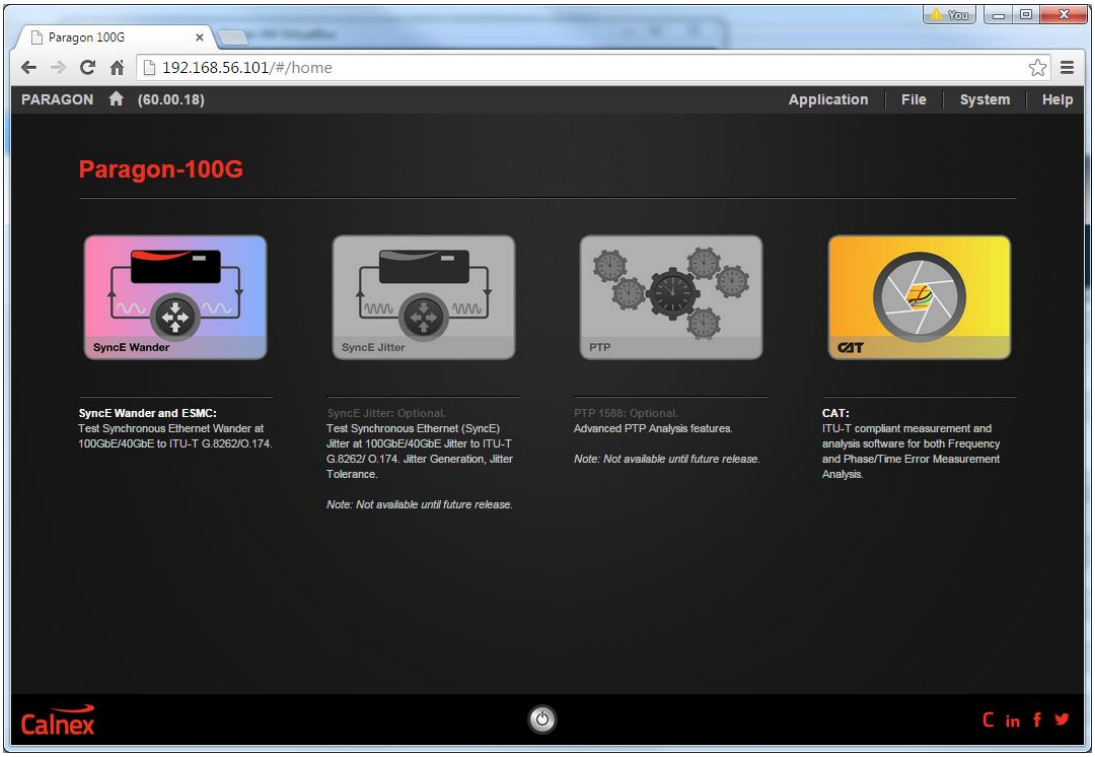
Paragon-100G Clock Reference Inputs (Front Panel)

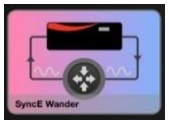
There are two reference inputs:

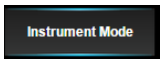
- J4 unbalanced: BNC with 75Ω impedance (connector on the left)
- J5 balanced: RJ connector with 100Ω or 120Ω impedance (connector on the right)

3. How to Configure the Paragon-100G for ALL G.8262 Wander Tests

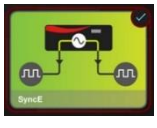
1. Verify the physical connections have been completed as described in Section 2.
2. Start the Paragon-100G GUI by connecting to the Calnex Paragon-100G, enter the IP address shown on the front panel status display into your browser address bar, and then the user interface should be displayed as shown below.



3. Select  (***SyncE Wander***)

4. Select 

5. Select  (***Tx + Rx Mode)***

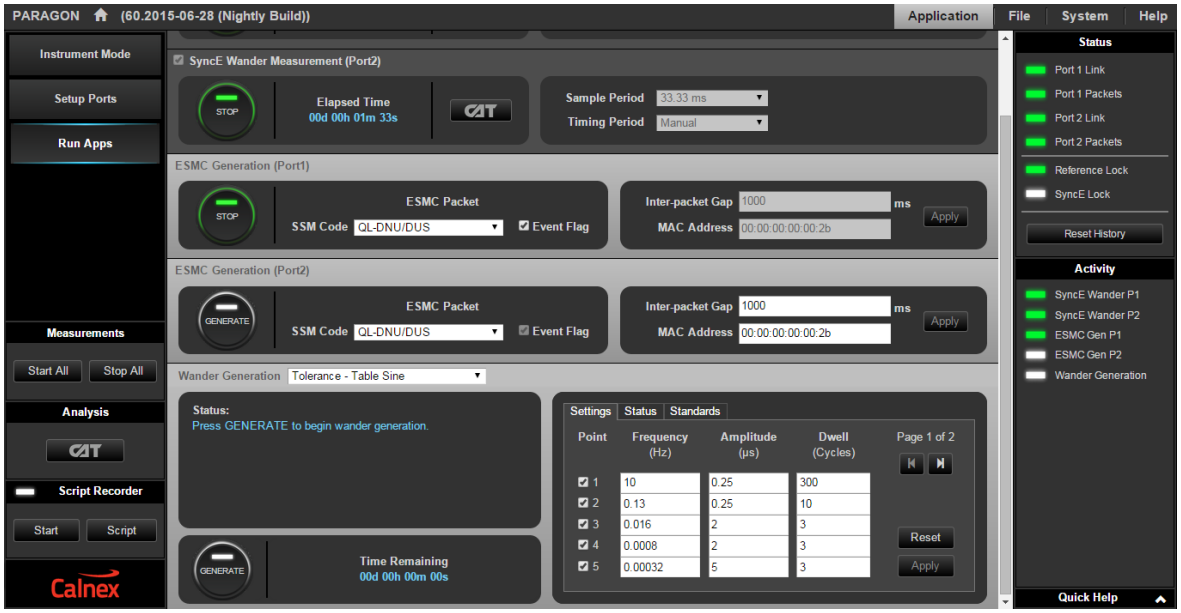
6. Verify that (***using not*** selected.  ***Internal or External Clock)*** is selected and that ***Clock is recovered from Rx > Tx*** is

7. Select **Setup Ports**, then **References** and select the required external Clock Reference Input.

8. Select the **Ethernet** tab, then select the desired Optical Interface from the interactive graphic.

   Note: If using QSFP28 then the optical interface module needs to be an LR4 (4 x 25G) module. Similarly, CXP optical interface module is SR10 (10 x 10G).

9. Select **Run Apps**.

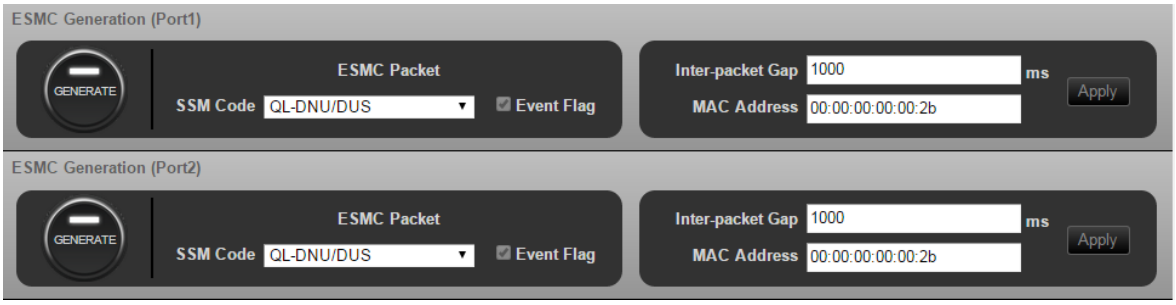


Note: Once you have selected this, **Port 1 Link** and **Port 2 Link** Status should be green. **Port 1 Packets** and **Port 2 Packets** Status should be green. The **Reference Lock** should be green. The Paragon-100G GUI will display **SyncE Lock** as white (this verifies that the ***Clock is recovered from Rx > Tx*** box is unchecked, meaning that the Paragon-100G is using its internal or external clock. If ***Clock is recovered from Rx > Tx*** is selected in the required Tx+Rx mode, then there would be no clock).

ESMC Generation

Ethernet Synchronization Message Channel (ESMC) is a Point to Point Protocol in which each EEC generates and terminates an ESMC PDU. This ESMC PDU is normally transmitted once per second on the Slow Protocol Channel and contains the Quality Level (QL) of the associated clock. The receiving EEC uses this QL to select the best quality clock. The EEC then regenerates the ESMC PDU with the appropriate QL TLV value to indicate the quality of the clock being transmitted to the next EEC.

Note: If the EEC supports ESMC, it is possible for the Paragon-100G to use this functionality to indicate if an EEC switches clock reference or goes into holdover.



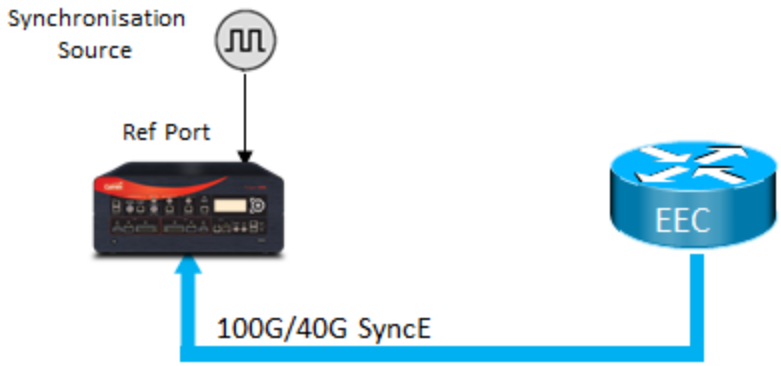
The Paragon-100G can generate ESMC messages on both Ports 1 and 2. For G.8262 conformance testing, ESMC messages are generated on Port 2 with a user-defined Quality Level (QL) such as PRC.

1. Select **Port 2** tab (the output from the Paragon-100G and input to EEC).
2. Select **SSM code** to QL-PRC, which tells the EEC that the clock from the Paragon-100G is of PRC quality.
3. Check the **Inter-packet Gap** and if it is not 1000ms then set **Inter-packet Gap** to 1000ms and then select **Apply**. This sets the Paragon-100G to send ESMC packets once per second.
4. Generate ESMC messages by selecting the 

button. The button will turn green to indicate the Paragon-100G is generating ESMC packets.

   Note: After any setup changes to the Paragon-100G, ensure the EEC has had time to settle before making any measurements.

4. Measuring Frequency Accuracy – G.8262 Section 6



	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	Free run	±4.6ppm	Recommend to test for an hour, longer if close to limits.
EEC Option 2	Holdover	±4.6ppm	Recommend to test for an hour, longer if close to limits.

Measurement Process

1. Connect the EEC to Paragon-100G as shown above.
2. Set up the Paragon-100G GUI as described in Section 3.
3. Select **Run Apps**.

4. Select the 

button on the connected port (Port 1 or Port 2) to start the measurement.

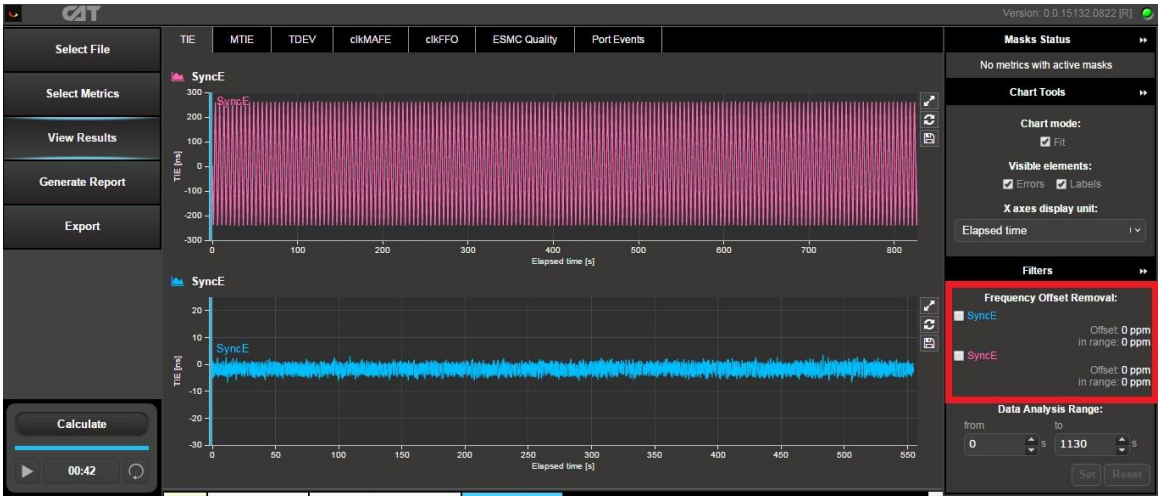
5. To stop the measurement after a pre-defined period for running the test, select the 

button.

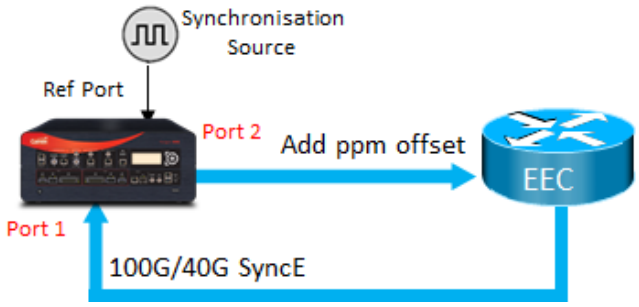
6. Select 

to pull up the results in a separate TAB on the browser.

7. The CAT will provide the ppm frequency accuracy in the **Frequency Offset Removal** section at the right of the graph shown below in the red highlighted box.



5. Pull-in, Hold-in and Pull-out ranges – G.8262 Section 7



Pull–in Range (G.8262 Section 7.1)

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

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

Hold–in Range (G.8262 Section 7.2)

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

	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	Not Applicable		
EEC Option 2	EEC is locked to the clock from the Paragon-100G. The frequency is then offset to ±4.6ppm.	EEC should remained locked at an offset at ±4.6ppm.	Lock can also be monitored by using ESMC (if supported).

Pull–out Range (G.8262 Section 7.3)

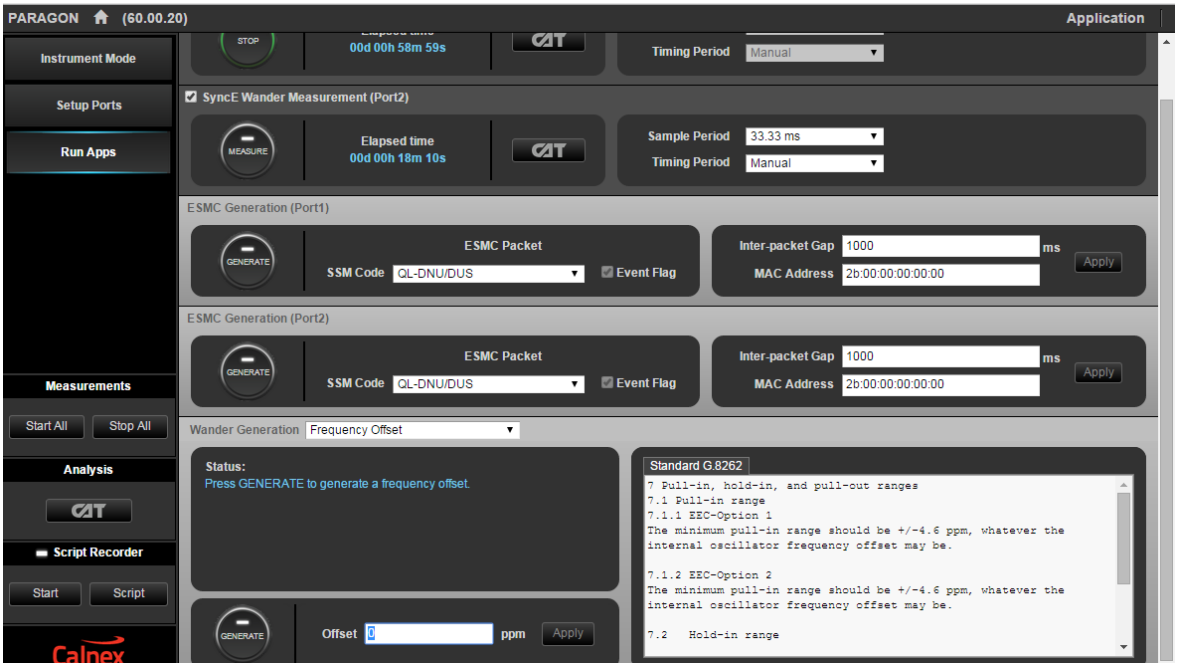
Pull-out range is defined as the offset between a slave clock's reference frequency and a specified nominal frequency, within which the slave clock stays in the locked mode and outside of which the slave clock cannot maintain locked mode, irrespective of the rate of the frequency change.

	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	EEC is locked to the clock from the Paragon-100G. The frequency is then offset until the EEC unlocks.	EEC should remain locked at an offset at ±4.6ppm but lock should extend beyond this.	G.8262 states this is for further study.
EEC Option 2	Not Applicable		

Measurement Process

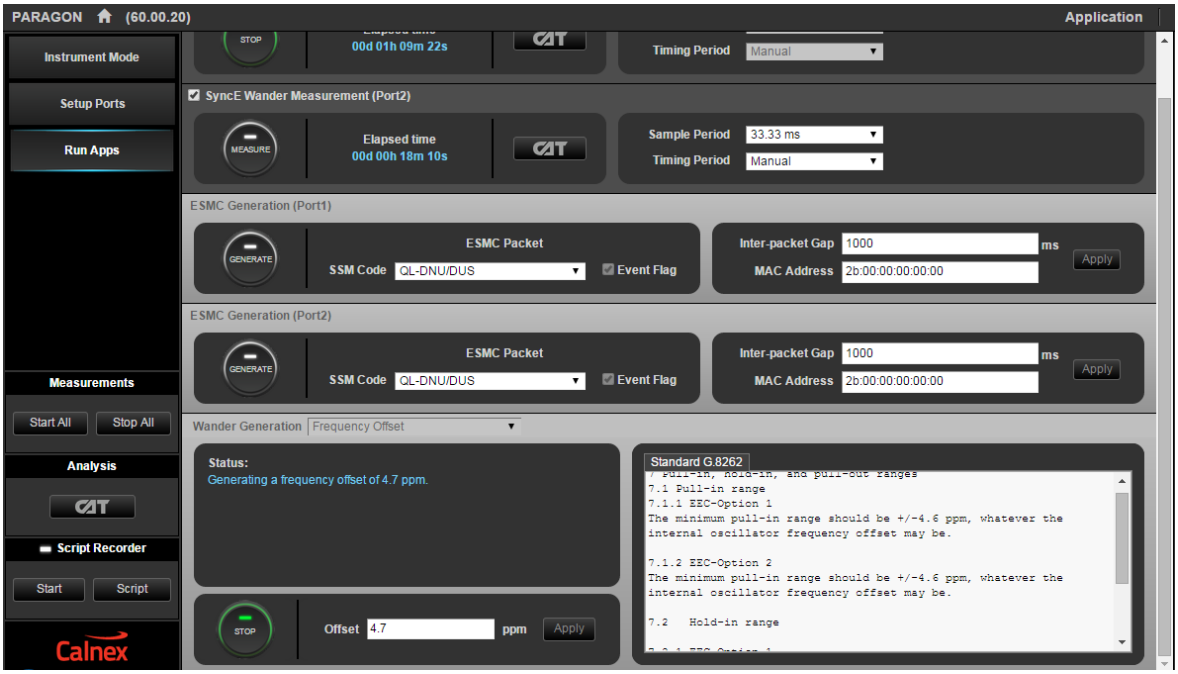
1. Connect the EEC to the Paragon-100G as shown in the diagram at the beginning of this section.
2. Set up the Paragon-100G GUI as described in Section 3, including setting up ESMC with QL=PRC if using ESMC to monitor which clock the EEC is locked to.
3. Select the 

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 

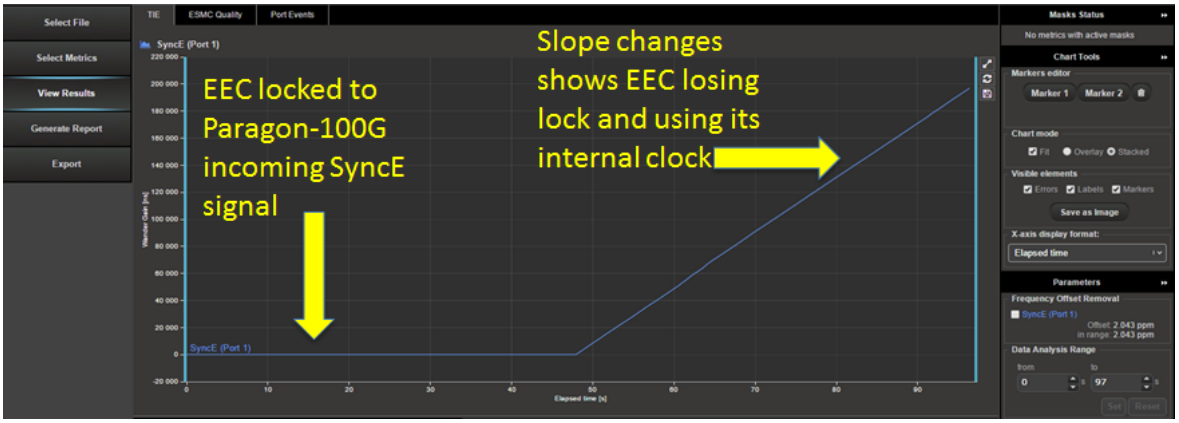
button.



6. To stop the measurement after a pre-defined period for running the test, select the  button.

7. Select  to pull up the results in a separate TAB on the browser.

8. The Paragon-100G TIE graph indicates if the EEC is in or out of lock as shown below.



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

	Input Stimulus	Pass/Fail Criteria	Notes (G.8262 masks)
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	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	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	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)”. This will not be covered in this section.

Measurement Setup

1. Connect the EEC to Paragon-100G to EEC as shown in the diagram at the beginning of this section.
2. Set up the Paragon-100G as described in Section 3, including setting up ESMC with QL=PRC if using ESMC to monitor which clock the EEC is locked to.

Measurement Process

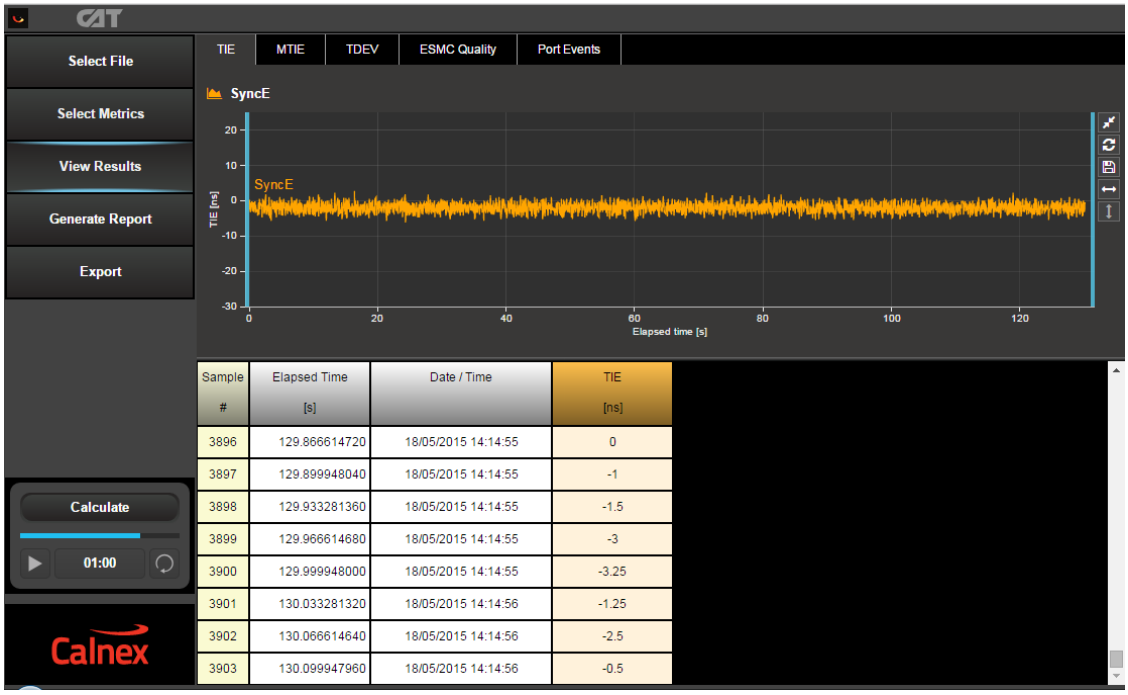
1. Select the 

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

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

to pull up the results in a separate TAB on the browser.

The graph will show the captured TIE.



Sample #	Elapsed Time [s]	Date / Time	TIE [ns]
3896	129.866614720	18/05/2015 14:14:55	0
3897	129.899948040	18/05/2015 14:14:55	-1
3898	129.933281360	18/05/2015 14:14:55	-1.5
3899	129.966614680	18/05/2015 14:14:55	-3
3900	129.999948000	18/05/2015 14:14:55	-3.25
3901	130.033281320	18/05/2015 14:14:56	-1.25
3902	130.066614640	18/05/2015 14:14:56	-2.5
3903	130.099947960	18/05/2015 14:14:56	-0.5

4. To display the MTIE graphs, press Select Metrics then check the MTIE and TDEV tick boxes.

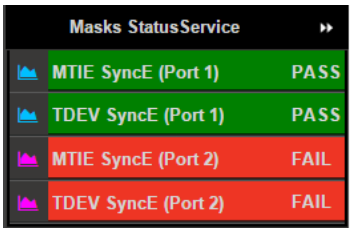
5. Now press View Results on the left hand side of the graph, select **MTIE** from the tabs at the top and then press the play ▶ button on the Calculate box.

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

6. To display the TDEV graph, press View Results on the left hand side of the graph, select **TDEV** from the tabs at the top and then press the play ▶ button on the Calculate box.

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

8. Pass/Fail indication against the masks is shown to the right under **Mask Status Service** with text highlighted in green for a "Pass" and text highlighted in red for a "Fail" as follows:

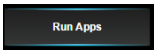


7. Jitter Generation – G.8262 Section 8.3

	Input Stimulus	Pass/Fail Criteria	Notes
25G lanes (100GbE LR4)	• None, unless device requires packet stream to function.	Output Jitter ≤1.2UIpp in 60-second window, as G.8262 8.3, Table 6.	Measurement filter bandwidth: 20kHz to 200MHz as specified in G.8262 8.3, Table 6.
10G lanes (100GbE SR10, 40GbE)	• None, unless device requires packet stream to function.	Output Jitter ≤0.5UIpp in 60-second window, as G.8262 8.3, Table 6.	Measurement filter bandwidth: 20kHz to 80MHz as specified in G.8262 8.3, Table 6.

Measurement Setup

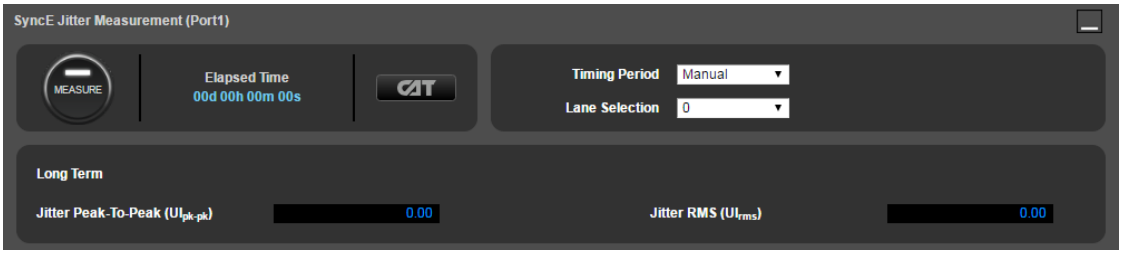
1. Connect the EEC to Paragon-100G as shown in the diagram at the beginning of this section.
2. Set up the Paragon-100G as described in Section 3.
3. On the Paragon-100G Home page, select **SyncE Jitter**.

4. Select the 

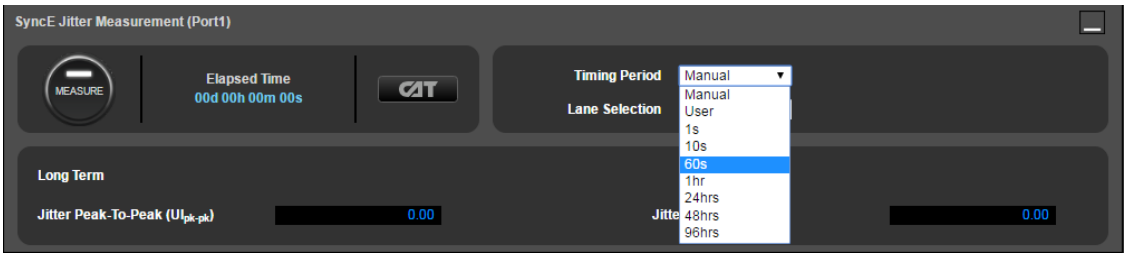
button on the Paragon-100G user interface.

Measurement Process

1. Select **Jitter Measurement**.

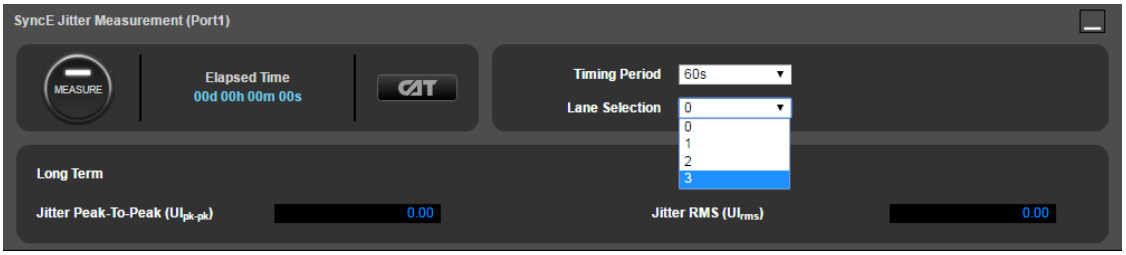


2. G.8262 specifies a peak-to-peak (pp) jitter measurement time of 60s. Select **Timing Period**, **60s**.



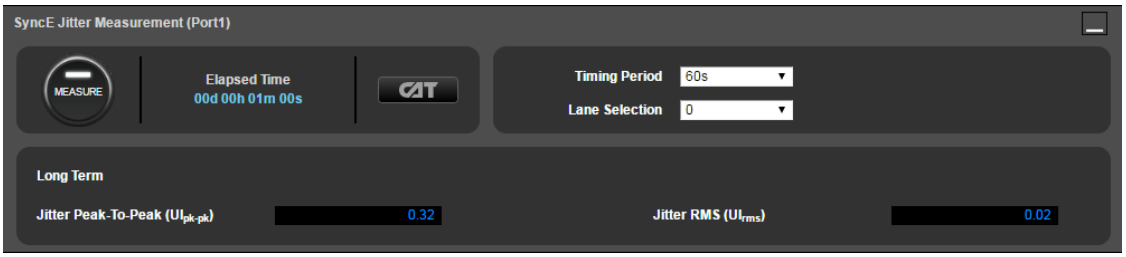
Select other periods or manual if required, e.g. for experimentation and observing long-term device behaviour. However, 60s must be selected for making a G.8262 compliance measurement.

3. Select the required **Lane Selection**. There are four 25G lanes in a 100GbE LR4 interface and ten 10G lanes in a 100GbE SR10 interface. These could exhibit different jitter characteristics, therefore, it is recommended to verify the jitter performance on each lane.

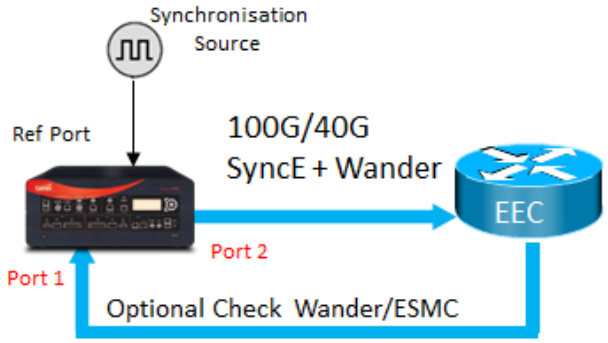


4. Select the 

button on Port 1 to start the measurement. The result displayed is the peak to peak and RMS jitter results. The measurement bandwidth is fixed at 20kHz - 200MHz for 100GbE LR4 interfaces or 20kHz - 80MHz for 100GbE SR10 interface.



8. Wander (Noise) Tolerance – G.8262 Section 9

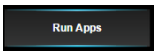


	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	• MTIE Wander Table 7, Figure 5 • TDEV Wander Table 8, Figure 6 • Sinusoidal Wander Table 9, Figure 7	The EEC is i. Maintaining the clock within performance limits. ii. Not causing any alarms. iii. Not causing the clock to switch reference. iv. Not causing the clock to go into holdover.	To check whether the EEC is switching references or going into holdover, the Paragon can measure the wander and/or ESMC QL of the EEC output.
EEC Option 2	• TDEV Wander Table 10, Figure 8	The EEC is i. Maintaining the clock within performance limits ii. Not causing any alarms. iii. Not causing the clock to switch reference. iv. Not causing the clock to go into holdover.	To check whether the EEC is switching references or going into holdover, the Paragon can measure the wander and/or ESMC QL of the EEC output.

Measurement Setup

1. Connect the EEC to Paragon-100G as shown in the diagram at the beginning of this section.
2. Set up the Paragon-100G as described in Section 3, including setting up ESMC with QL=PRC if using ESMC to monitor if the EEC is switching clock references or going into holdover.

Measurement Process

1. Select the 

button on the Paragon-100G GUI.
2. Now select one of the Tolerance selections in the **Wander Generation** pull down selection.

There are three methods of generating wander into the EEC:

- **"Tolerance – G.8262 Option MTIE/TDEV"** Wander – fastest and most effective way to evaluate EEC
- **"Tolerance Table Sine"** : Table Sinusoidal Wander – can be used for finding Maximum Tolerable Wander
- **"Tolerance Single Sine"** : Single Sinusoidal Wander – can be used for troubleshooting

3. **MTIE/TDEV Wander**

   The Paragon-100G generates MTIE and TDEV Wander as defined in G.8262.

   a) Select the wander mask required from the drop down list. The mask and the maximum running time will be shown on the right hand side of the window.

   - G.8262 Option 1 MTIE – Running Time is 1000s (16mins 40secs)
   - G.8262 Option 1 TDEV – Running Time is 12000s (3hours 20mins)
   - G.8262 Option 2 TDEV – Running Time is 12000s (3hours 20mins)

   b) Under **Wander Generation**, click 

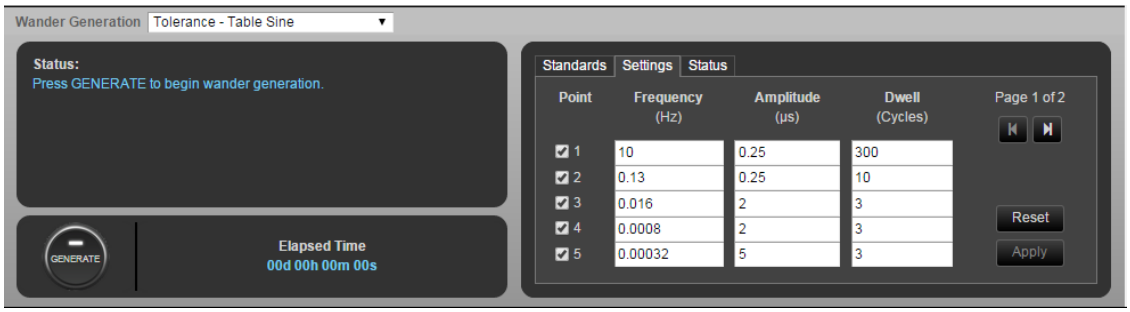
to start the test. The remaining time will be displayed beside the Generate/Stop button.

   c) The test will stop after the maximum running time has elapsed. The test can also be stopped manually under **Wander Generation** by selecting 

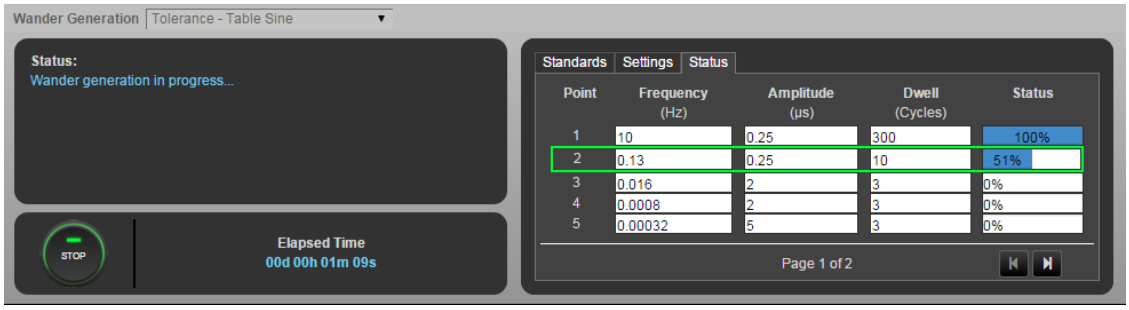
.

4. **Tolerance - Table Sine**

Can be used to test Maximum Tolerable Wander.



You can enter up to 10 different wander parameter sets in the table. The Paragon-100G will then automatically add each of the specified wander sets in turn, giving full indication of progress in the **Status** column.



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

a) 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 that 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, "un-tick" the **Point** check box for that selection.

b) Under Wander Generation click 

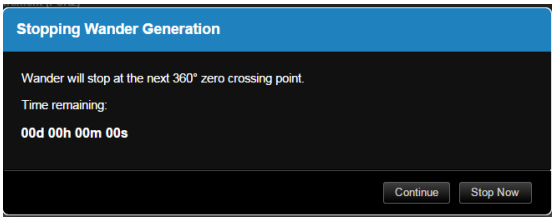
to start the test.

c) The test can also be stopped manually under Wander Generation by selecting 

.The test will terminate at the next zero crossing.

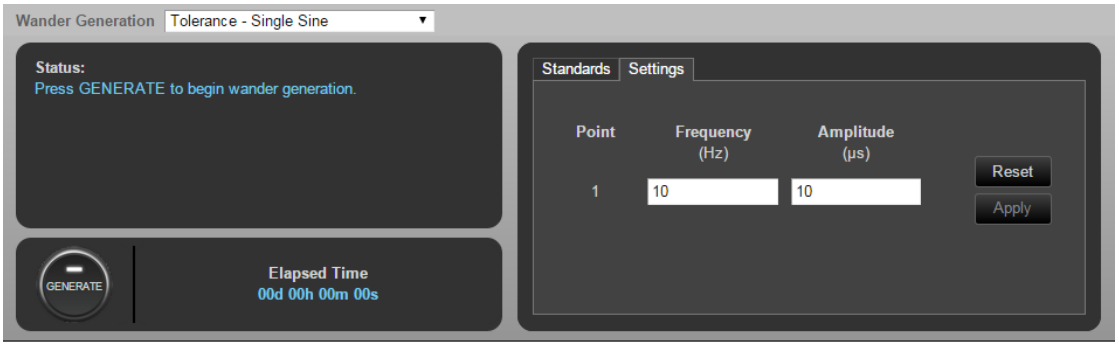
d) A pop up box stating how long to the next zero crossing is displayed. Click the 

button if you want to stop the test instantly.



5. **Single Sinusoidal Wander**

   Can be used for troubleshooting issues at a specific frequency.



   a) Enter the frequency and amplitude of the desired wander.

   b) Click 

to start the test.

   c) Click 

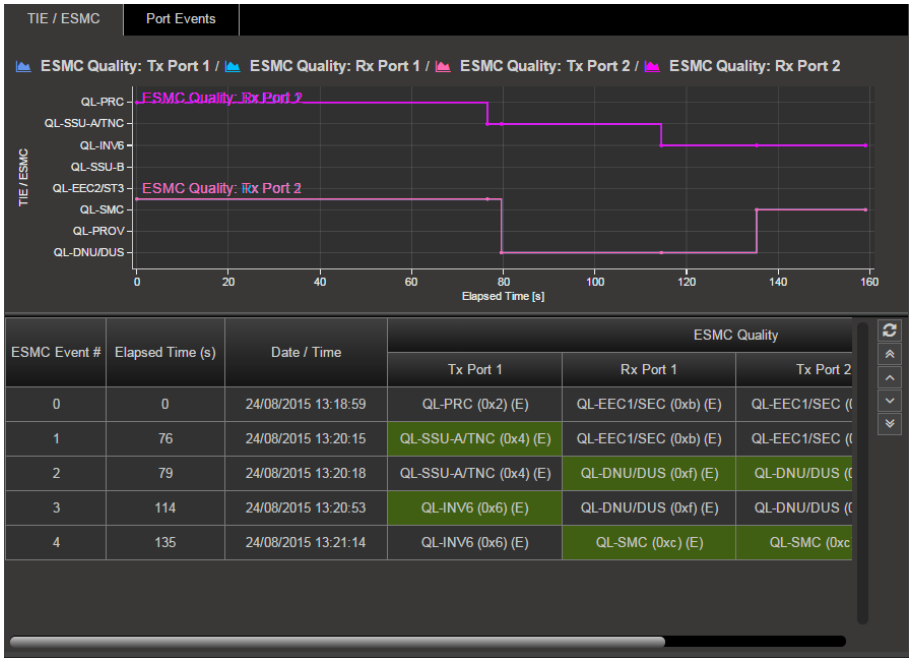
to stop the test. The test will terminate at the next zero crossing of the wander frequency, and a pop up box stating how long to the next zero crossing is displayed.

6. G.8262 states that with the wander applied that the EEC should:
   - Maintain the clock within the prescribed performance limits (the exact performance limits are for further study)
   - Not cause any alarms
   - Not cause the clock to switch references
   - Not cause the clock to go into holdover

   For further insight, use the Paragon-100G ESMC generation/capture capability and TIE graph to check whether the EEC is switching clock reference or going into holdover.

7. Ensure the Paragon-100G has been set up to Generate ESMC messages with QL=PRC as described in Section 3 of this document.

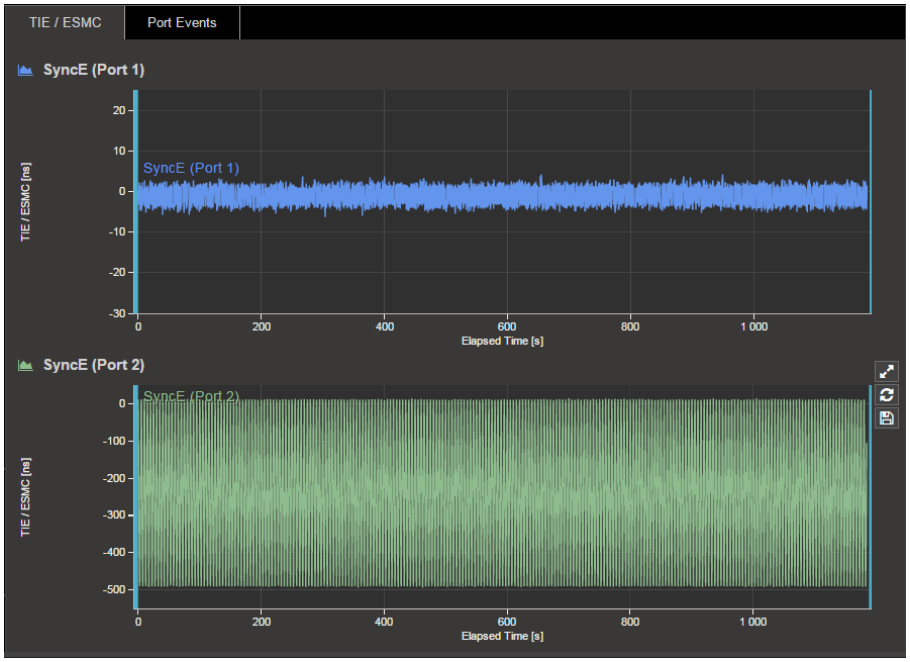
8. Select the MEASURE button to start the measurement. To show the ESMC graph select CAT then click View Results and then TIE / ESMC.



ESMC Event #	Elapsed Time (s)	Date / Time	ESMC Quality		
			Tx Port 1	Rx Port 1	Tx Port 2
0	0	24/08/2015 13:18:59	QL-PRC (0x2) (E)	QL-EEC1/SEC (0xb) (E)	QL-EEC1/SEC ((
1	76	24/08/2015 13:20:15	QL-SSU-A/TNC (0x4) (E)	QL-EEC1/SEC (0xb) (E)	QL-EEC1/SEC ((
2	79	24/08/2015 13:20:18	QL-SSU-A/TNC (0x4) (E)	QL-DNU/DUS (0xf) (E)	QL-DNU/DUS ((
3	114	24/08/2015 13:20:53	QL-INV6 (0x6) (E)	QL-DNU/DUS (0xf) (E)	QL-DNU/DUS ((
4	135	24/08/2015 13:21:14	QL-INV6 (0x6) (E)	QL-SMC (0xc) (E)	QL-SMC (0xc

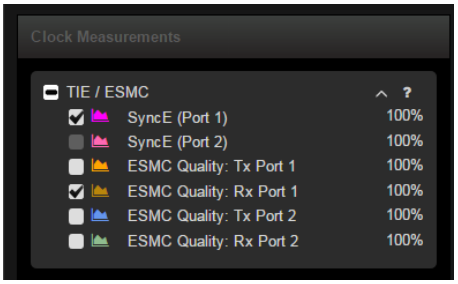
a) To show the TIE graph, select CAT then click View Results and TIE / ESMC.

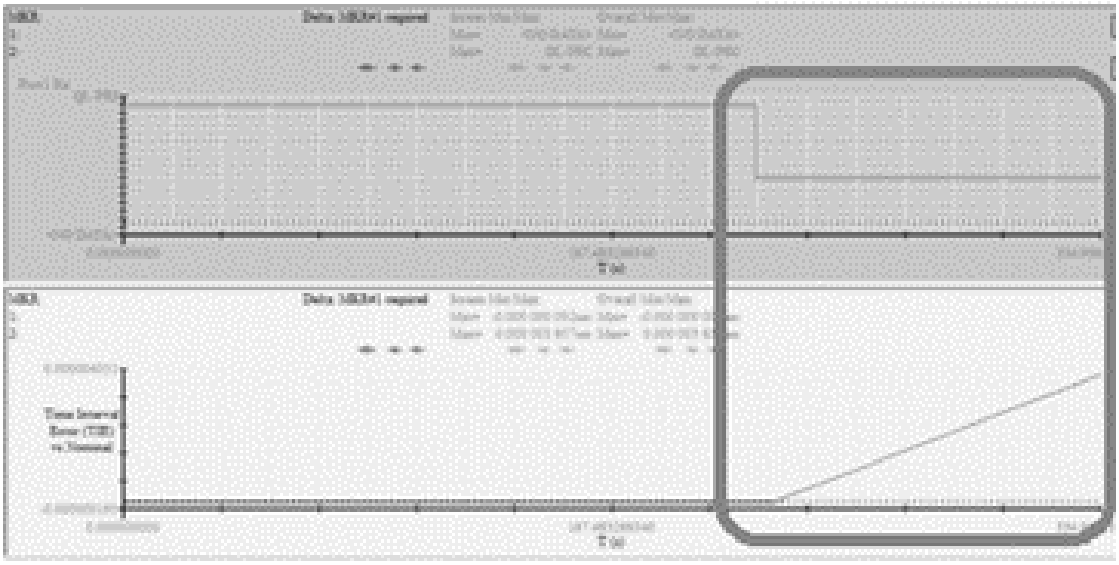
b) Double-click either the SyncE (Port 1) or SyncE (Port 2) TIE graph (the selected graph will expand and the TIE data will be shown underneath the graph).



c) Click 

and then by selecting the TIE/ESMC drop down, choose the required results to display in this case SyncE (Port 1) and ESMC Quality: Rx Port 1.



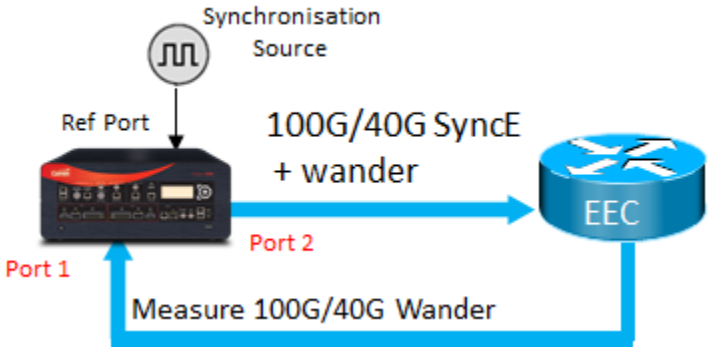


The screenshot above shows an EEC that has switched references or gone into holdover (top graph is ESMC, bottom graph shows the difference in Frequency between the reference and the recovered clock from the EEC).

9. To stop the measurement, on the main Paragon-100G GUI select the 

button.

9. Wander (Noise) Transfer – G.8262 Section 10



	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	Not defined.	The phase gain of the EEC should be smaller than 0.2dB (2.3%).	There is no definition of the input stimulus to be used in G.8262. Without further guidance from the Standards, it is suggested that the amplitude and frequency values associated with mask points labelled f1, f2 and f3 on G.8262 Section 9.1.1, Table 9 and Figure 7 are used. Other values may be used as guided by the manufacturer.
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 13, Figure 11.	

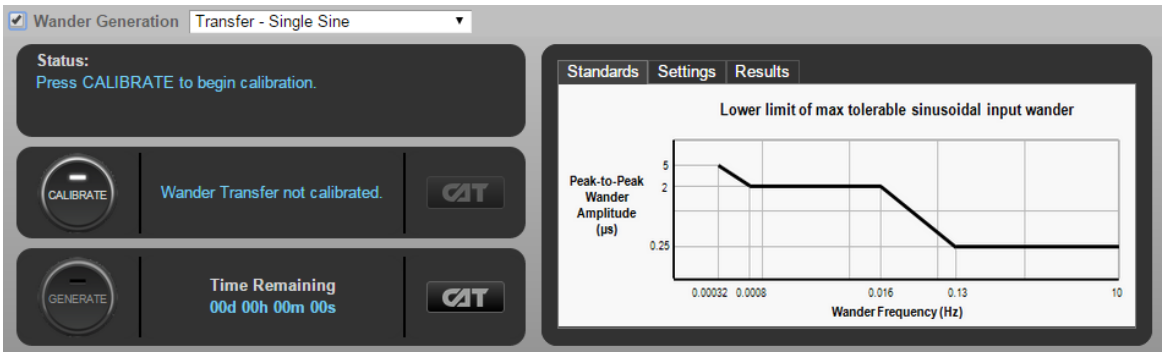
Measurement Setup

1. Connect the EEC to Paragon-100G to EEC as shown in the diagram at the beginning of this section.
2. Set up the Paragon-100G as described in Section 3, including setting up ESMC with QL=PRC if using ESMC to monitor which clock the EEC is locked to.

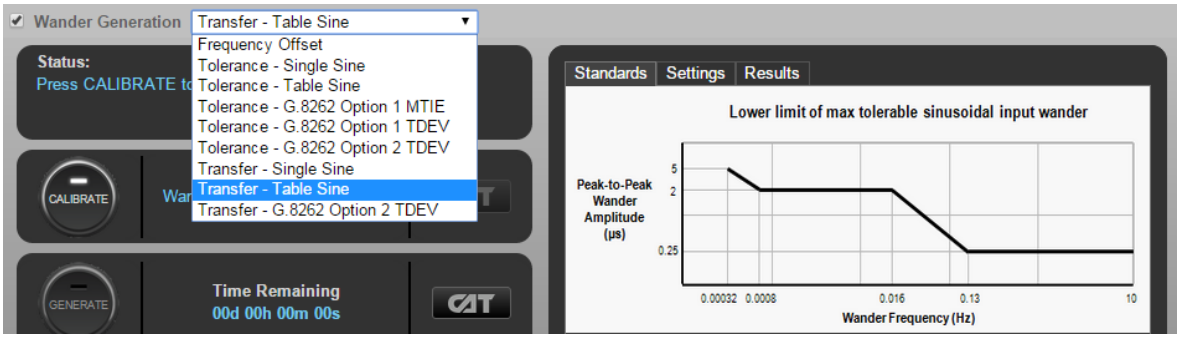
Measurement Process

1. Tick the **Wander Generation** check box on the Paragon-100G GUI. Note, you may have to stop a running measurement and then tick the Wander Generation selection (as you need to free up a measurement port for Wander Generation).

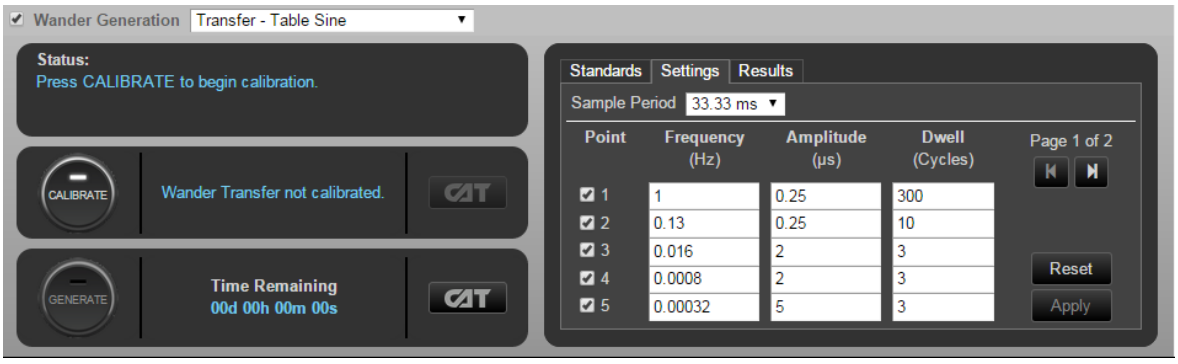
2. The following window will now be shown.



3. Select **Transfer – Table Sine** from the drop down menu.

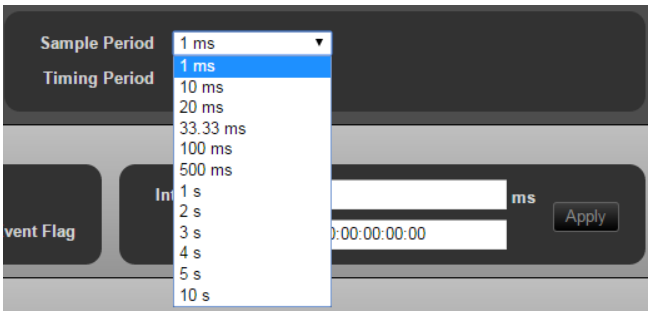


4. The following window should now appear; if you can't see the table then click **Settings** to reveal the table:



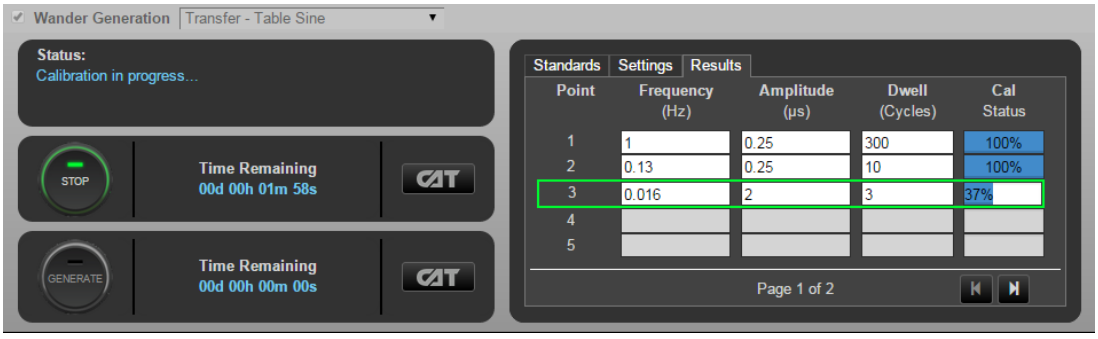
G.8262 Option 1 Wander Transfer Test: Paragon-100G automated testing

1. If you want to change from the default values in the table, enter the frequency, amplitude, and dwell time (number of cycles the frequency/amplitude pair will be run) for each wander transfer test point. Note:
   - The Reset button will restore the values to that defined in Table 9 of G.8262.
   - Only rows that have the ***enable*** check box ticked will be executed in the test. To skip over a selection, un-tick the enable box for that selection.
   - Be careful to choose a dwell time of 300 cycles for any wander frequency of 1 Hz or higher. Additionally, choose the shortest sample period available for calibration and definitive measurement runs.

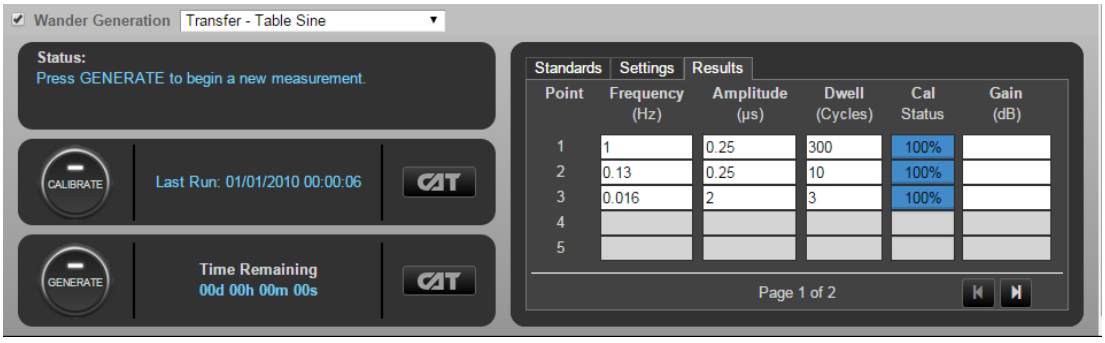


2. To calibrate the Paragon-100G, connect the appropriate optical cable between Port 1 and Port 2 and click the 

button and the "**Calibration in progress...**" status message will appear with the **Results** tab showing calibration progress.



3. When the calibration is finished the Results Table will show **Cal Status** for each calibration point as 100%. The **Status** message will also change to "**Press GENERATE to begin a new measurement.**"

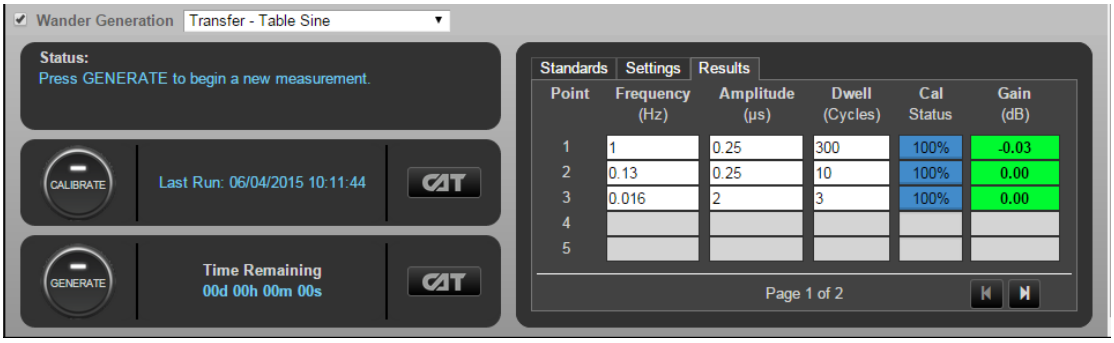


4. Remove the optical cable between Port 1 and Port 2 and connect the EEC under test as shown in the setup diagram at the start of this section.

5. Click the 

button to start the test.

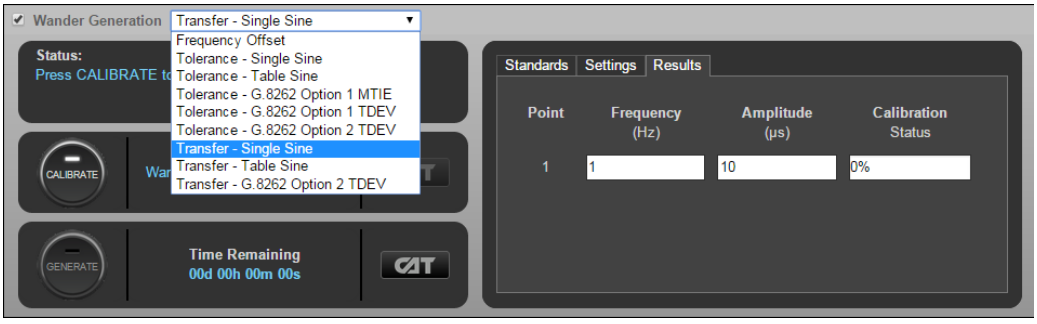
6. The Paragon-100G will show the estimated completion time at the bottom of the screen and will indicate the progress as it runs through the test, displaying the measured Gain (dB) value and also a Green (Pass)/Red (Fail) indication on the last (Gain) column.



G.8262 Option 1 Wander Transfer Test: Paragon-100G single frequency test

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

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

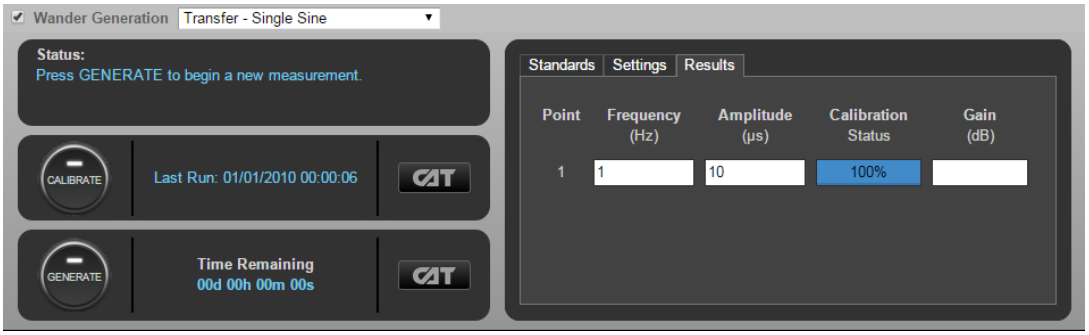


2. Enter the frequency and amplitude of the wander to be generated.

3. To calibrate the Paragon-100G, connect the appropriate optical cable between Port 1 and Port 2 and click the 

button and the "**Calibration in progress...**" status message will appear with the **Results** tab showing calibration progress.

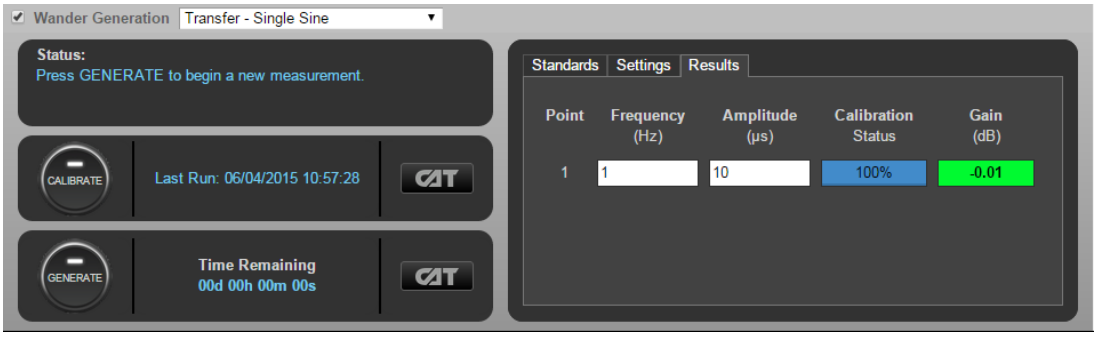
4. When the calibration is finished the Results Table will show **Cal Status** as 100%.The **Status** message will also change to "**Press GENERATE to begin a new measurement."**



5. Remove the optical cable between Port 1 and Port 2 and connect the EEC under test as shown in the setup diagram at the start of this section.
6. Click the 

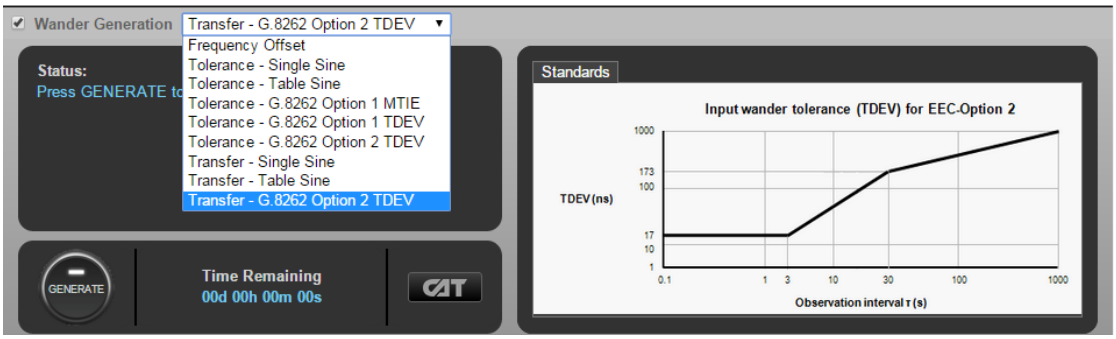
button to start the test.

7. The Paragon-100G 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 also a Green (Pass)/Red (Fail) indication on the last (Gain) column.



G.8262 Option 2 Wander Transfer Test

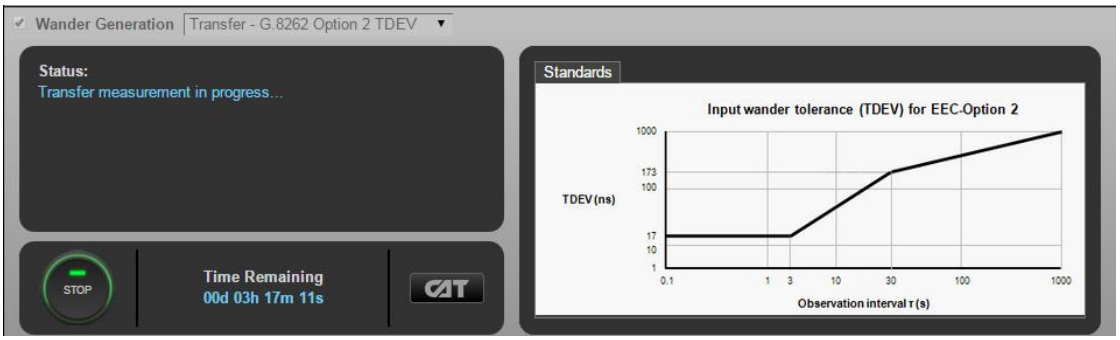
1. Select **Transfer – G.8262 Option 2 TDEV** from the drop down menu. This will display G.8262 TDEV Wander Tolerance mask for EEC-Option 2.



2. Click the 

button to start the test.

3. The amount of the time until completion of the test is shown at the bottom of the wander generation track.

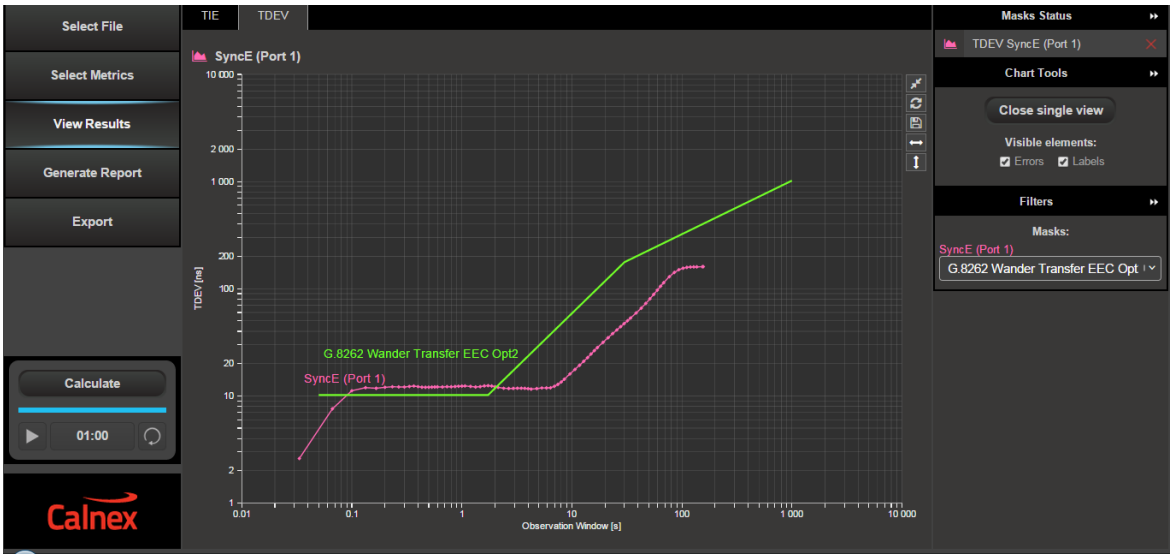


4. At any time during the test, it is possible to view an updated output TDEV graph. To display the TDEV results, select 

to view the results in a separate TAB in the browser.

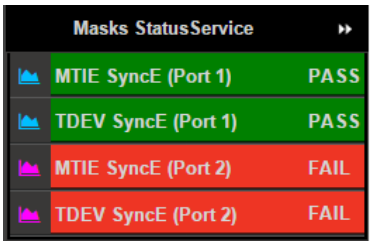
5. To display the TDEV graph click 

on the left hand side of the graph and then choose TDEV from the tabs at the top and then press the play  button on the **Calculate** box.

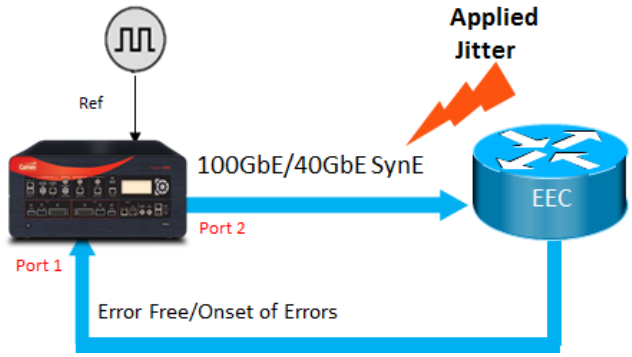


6. The TDEV results can be reviewed against the G.8262 masks by choosing the **G.8262 Wander Transfer** mask from the Metric Mask pull down menu under **Masks** at the right of the graph.

7. Pass/Fail indication against the masks is shown to the right under Mask Status Service with text highlighted in green for a “Pass” and text highlighted in red for a “Fail” as follows:



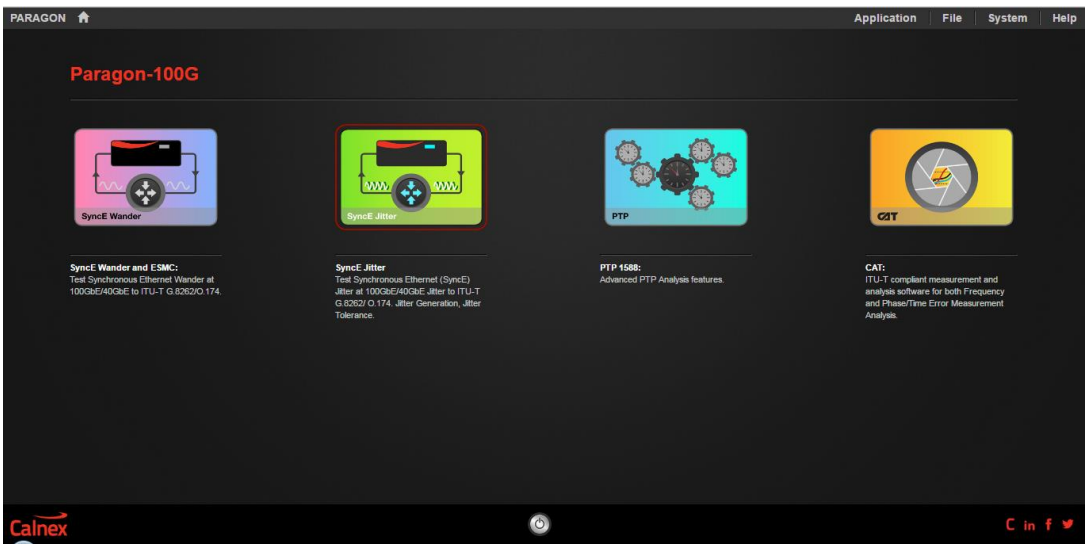
10. Jitter Tolerance – G.8262 Section 9.2

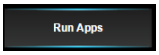


	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1 and **EEC Option 2**	• Test packet stream from Paragon-100G or thru-mode traffic. • Superimpose jitter to G.8262 9.2 Figure 9.	• The EEC does not drop packets for all jitter values presented. • The EEC does not Error/Alarm during the test for all jitter values presented. • The EEC does not go into Holdover during the test for all jitter values presented.	• Either as pass/fail with presented jitter values at the mask, or a margin test with jitter values above mask. • Allow settling time at each measurement point.

Measurement Setup

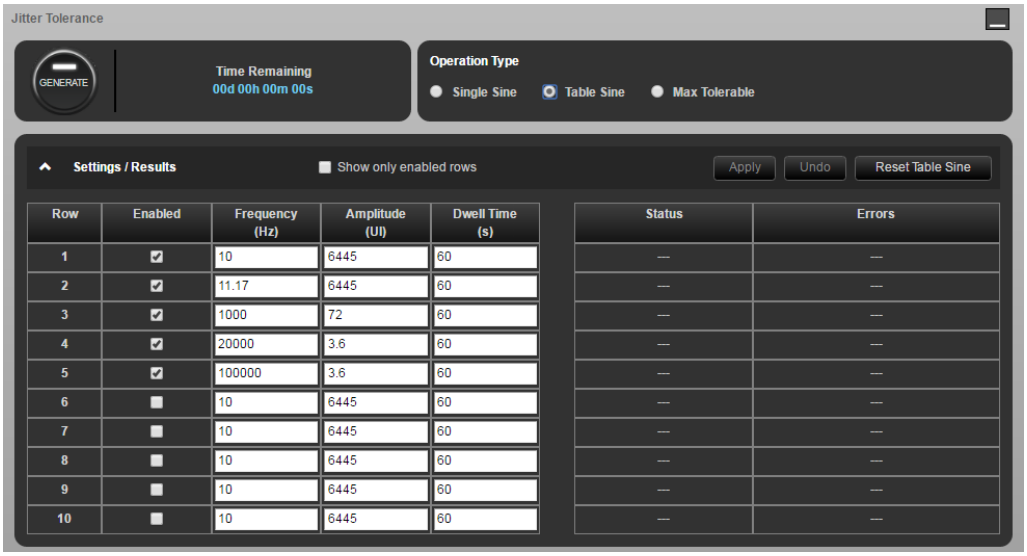
1. Connect the EEC to Paragon-100G as shown in the diagram at the beginning of this section.
2. On the Paragon-100G Home page, select **SyncE Jitter**.



3. Select the 

button on the Paragon-100G user interface, and then on the Jitter Tolerance panel, select **Table Sine**.

4. On the Jitter Tolerance Table, enter the **Frequency, Amplitude** and **Dwell Time** for each row. The User Interface lists default setting which can be used.



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

5. Select **Test Packet Settings** and configure the test packets generated by the Paragon-100G to meet your requirements. There are selections for Packet Size, Utilization and Payload plus Source and Destination MAC, and IP addresses.

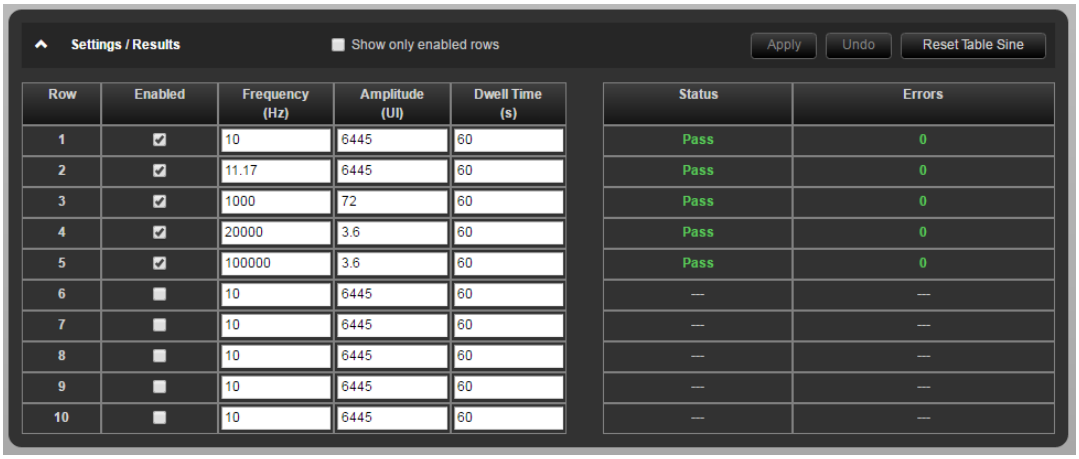
6. To start a Jitter Tolerance measurement, select 

. The Paragon-100G will now generate Jitter and Test Packets at the selected Jitter Frequency and Amplitude.

   If you need to manually stop the Jitter Tolerance measurement, then select the 

button. The test will, however, run to completion and stop itself without the need to stop the measurement.

7. A **Pass** or **Fail** result will appear for each enabled/disabled Frequency/Amplitude pairing after the test has stopped. The result will indicate if any dropped or out of sequence packets were detected during the Jitter Tolerance test.



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	—	—

8. The above test verifies that the EEC does not drop packets for all jitter values presented. However, it's also important to verify that the EEC does not Error/Alarm during the test for all jitter values presented. In addition, verify that the EEC does not go into Holdover during the test for all jitter values presented.

9. As a reference, the ITU-T G.8262 Jitter Tolerance table for **100G SR10 / 40G SR4 (10G)** is shown here:

Table 12 – 10G synchronous Ethernet wide-band jitter tolerance for EEC-Option 1 and EEC-Option 2

Peak-peak jitter amplitude (UI)	Frequency f (Hz)
2488	$10 < f \leq 12.1$
$30000\ f^{-1}$	$12.1 < f \leq 20$ k
1.5	20 k $< f \leq 40$ k
NOTE – 10G includes 10GBASE-SR/LR/ER, 10GBASE-LRM, 10GBASE-SW/LW/EW and multi-lane interfaces consisting of 10G lanes including 40GBASE-KR4/CR4/SR4/LR4 and 100GBASE-CR10/SR10	

For 100G SR10 (10G), as a minimum, the lowest frequency at 10Hz, the first knee at 12.1Hz, the next breakpoint at 20kHz and the maximum frequency at 40kHz should all be tested. It is preferable to test at additional frequencies.

The ITU-T G.8262 Jitter Tolerance table for **100G LR4 (25G)** is shown here:

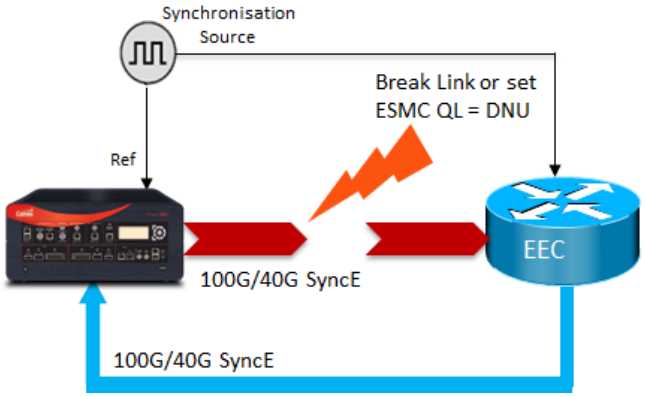
Table 13 – 25G synchronous Ethernet wide-band jitter tolerance for EEC-Option 1 and EEC-Option 2

Peak-peak jitter amplitude (UI)	Frequency f (Hz)
6445	$10 < f \leq 11.17$
$72000f^{-1}$	$11.17 < f \leq 20$ k
3.6	20 k $< f \leq 100$ k
NOTE – 25G includes multi-lane interfaces consisting of 25G lanes including 100GBASE-LR4/ER4.	

For 100G LR4 (25G), as a minimum, the lowest frequency at 10Hz, the first knee at 11.17Hz, the next breakpoint at 20kHz and the maximum frequency at 100kHz should all be tested. Again, it is preferable to test at additional frequencies.

11. Phase Transient Response – G.8262 Section 11

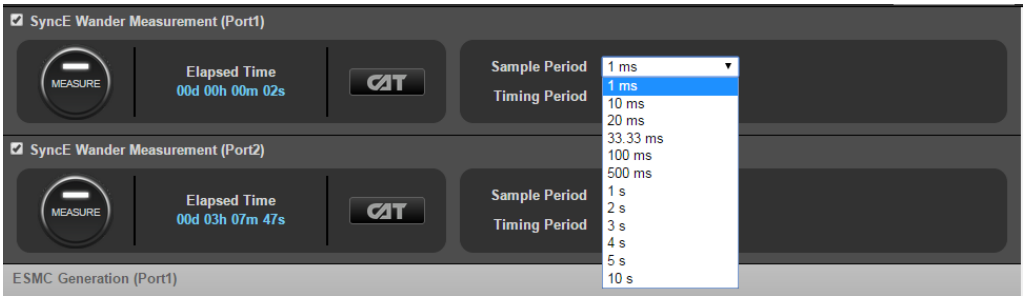
Short term phase transient response



	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	EEC input reference is lost for 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 • Remove the cable between Port 2 and EEC
EEC Option 2	EEC input reference is lost for 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=DNU • Remove the cable between Port 2 and EEC

Measurement Setup

1. Connect the EEC to Paragon-100G to EEC as shown in the diagram at the beginning of this section.
2. Set up the Paragon-100G as described in Section 3 (including ESMC generation if using the ESMC method of switching clock references, ensuring SSM code is set to PRC).
3. Open the **Sample Period** drop down menu and select a **1ms** sample period.



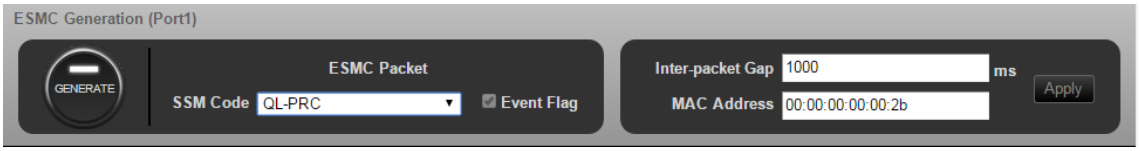
Measurement Process

There are two methods for determining Phase Transient Response with the Paragon-100G:

- Use ESMC Generation (if supported by the DUT).
- Remove the link between Port 2 on the Paragon-100G and the EEC input port.

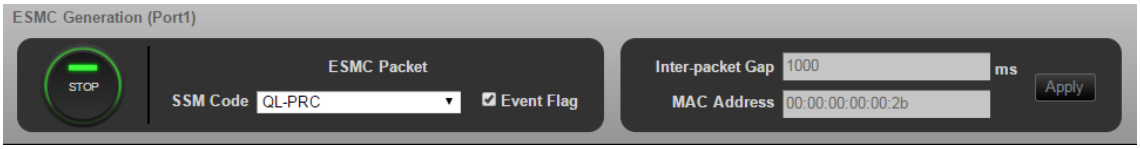
1. Select the 

button on SyncE Wander Measurement (Port 1) to start the measurement.
2. If using the Ethernet cable removal method, disconnect the cable between Port 2 and the EEC.
3. If using the ESMC method:
   a) Refer to the ESMC Generation track as shown below:

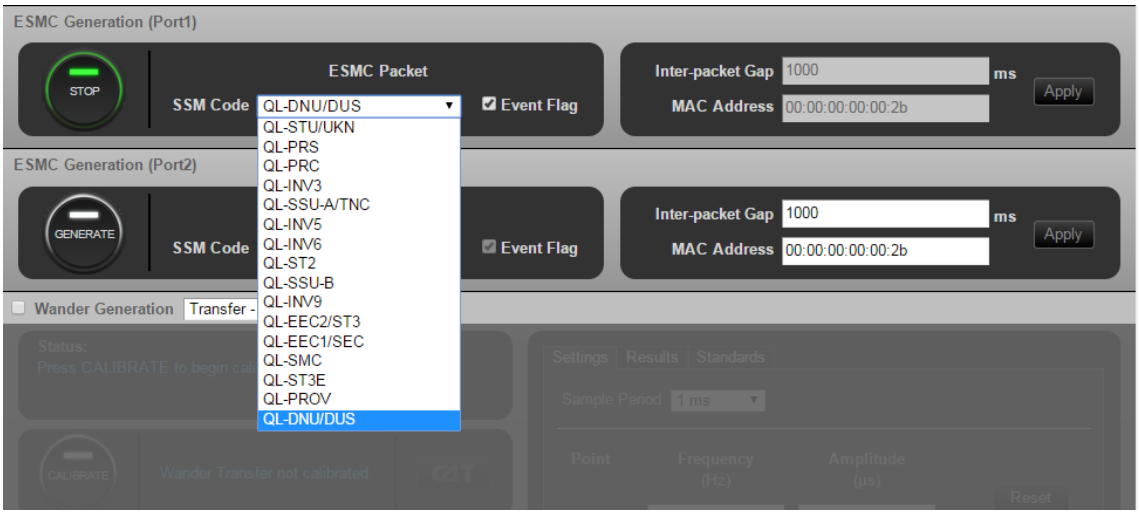


   b) Ensure SSM code is already set to **QL–PRC** and ensure the 

button is already selected.



   c) In the SSM Code drop down menu select **QL–DNU/DUS**.



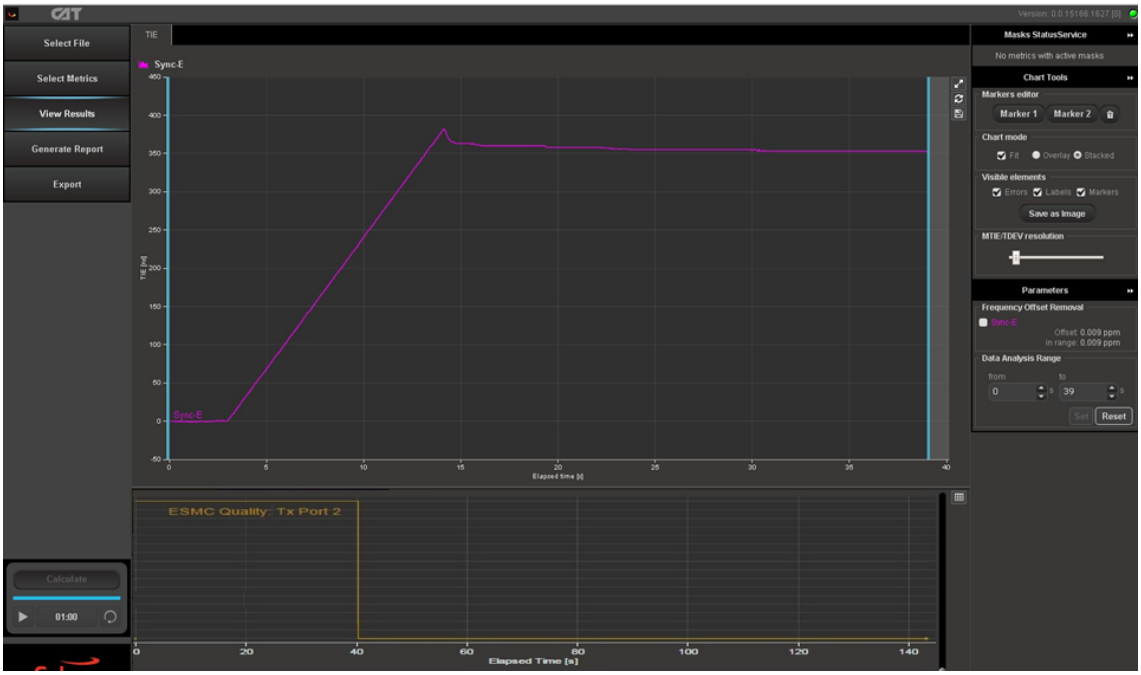
4. To stop the measurement, press the 

button on SyncE Wander Measurement (Port 1).

Measuring Results

The switching transient will be seen on the CAT TIE graph. The CAT graphs can show the TIE and also the ESMC QL for each port.

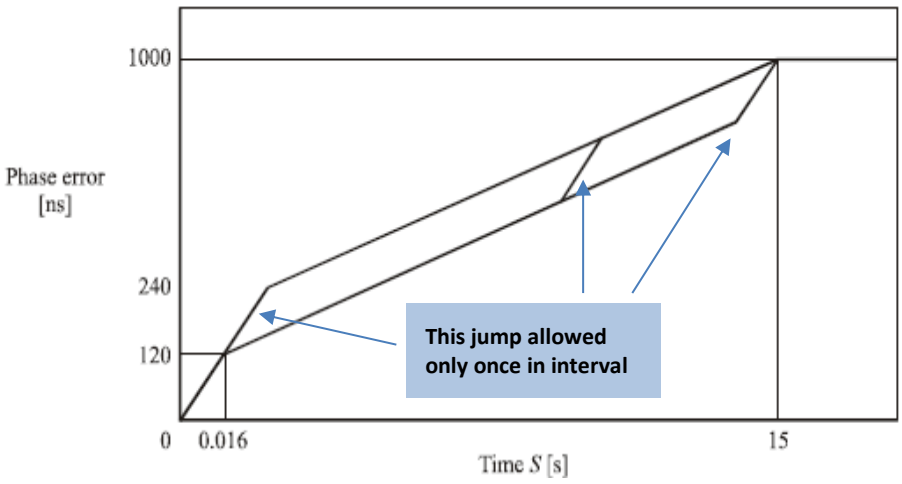
In the screenshot below the ESMC graph shows the time and QL change of the ESMC transition on Port 2 Tx of the Paragon-100G. This can then be compared in time to the TIE graph showing the Transient.



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

EEC Option 1

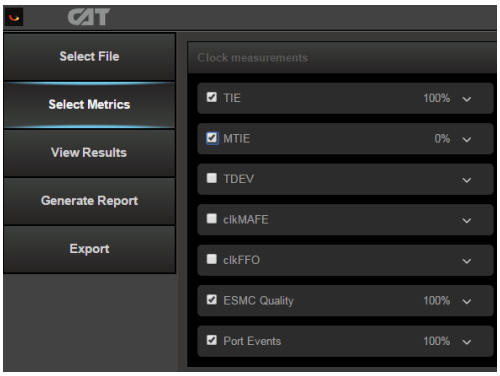
To view the output TIE for EEC Option 1, closely monitor the output TIE graph in Paragon-100G for the duration (15s) of the test. While the slave clock is acquiring the new reference, the output phase transient should be within the limits of Figure 12 of G.8262 (provided below).



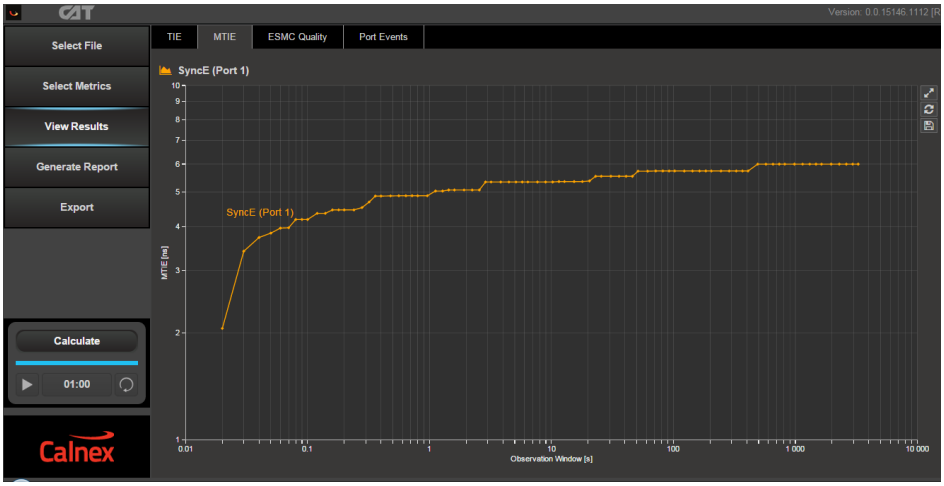
EEC Option 2

1. To view the output MTIE mask for EEC Option 2 **ONLY**, perform the following:
2. To display the MTIE and TDEV graphs select CAT under **Analysis** on the right hand side of the screen.
3. The CAT will open up in a separate TAB on the browser**.**

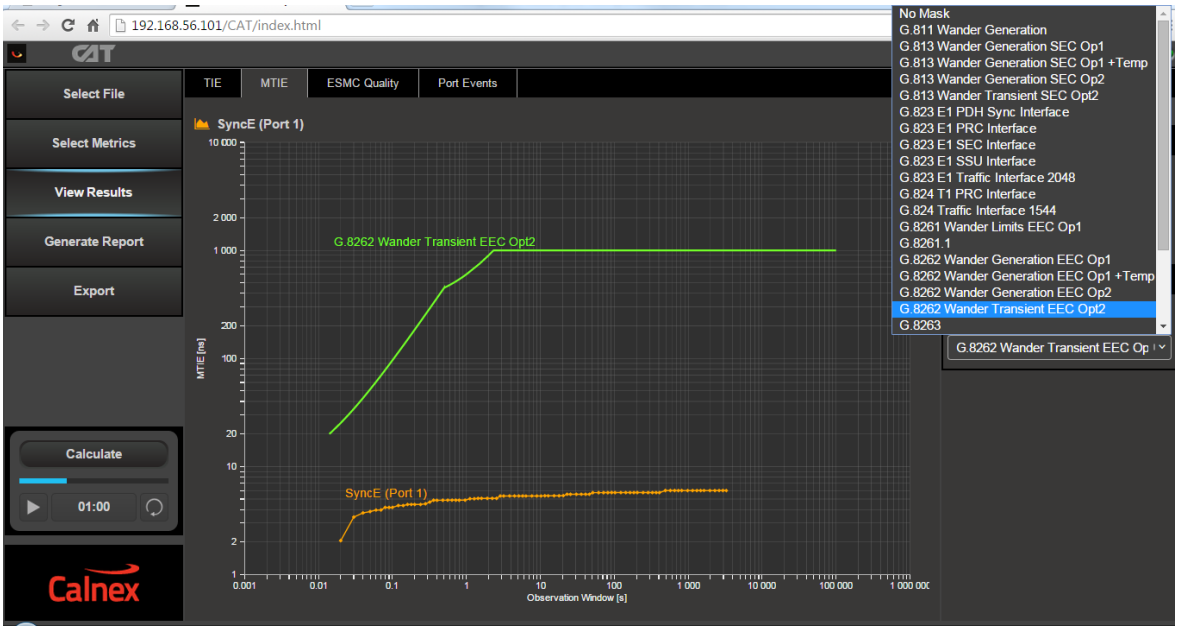
4. Choose **Select Metrics** and then tick the **MTIE** checkbox.



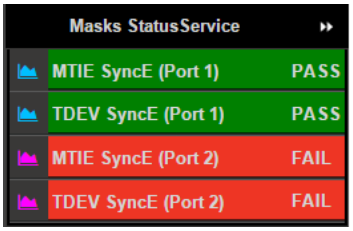
5. Select **View Results** then select the MTIE tab. Next, select the Calculate button on the left of the window. This will display the MTIE metrics graph.



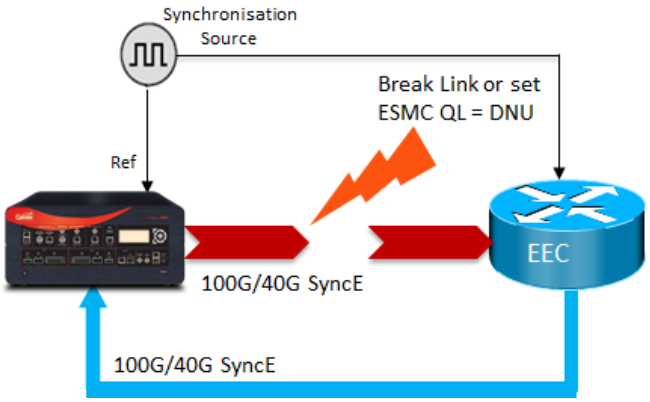
6. The MTIE analysis can be carried out against the G.8262 masks for Wander Transient which can be selected from the **Metric Mask** pull down selection at the bottom of the window.



7. Pass/Fail indication against the masks is shown to the right under Mask Status Service with text highlighted in green for a “Pass” and text highlighted in red for a “Fail” as follows:



Long-term phase transient response



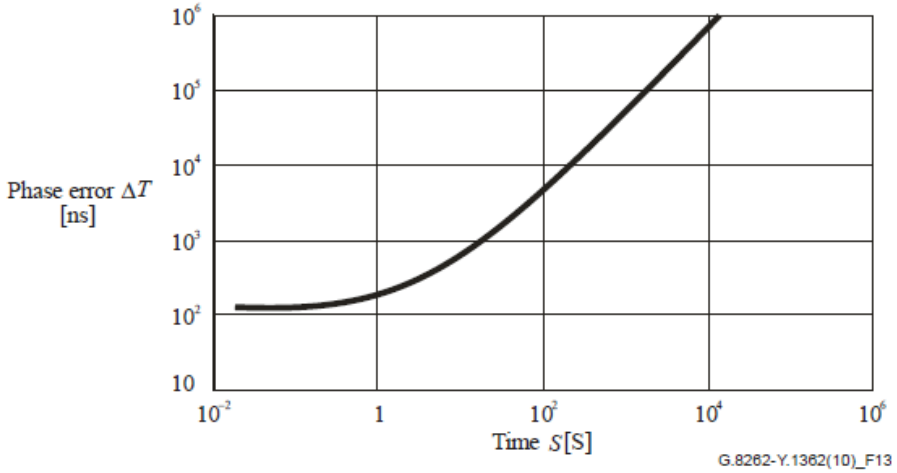
	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	EEC input reference is permanently lost or declared DNU.	Maximum phase transient and excursion at the output due to reference switching to meet mask in G.8262 Figure 13.	To emulate the loss of the link either: • Change ESMC QL=DNU • Remove the cable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

Measurement setup and process

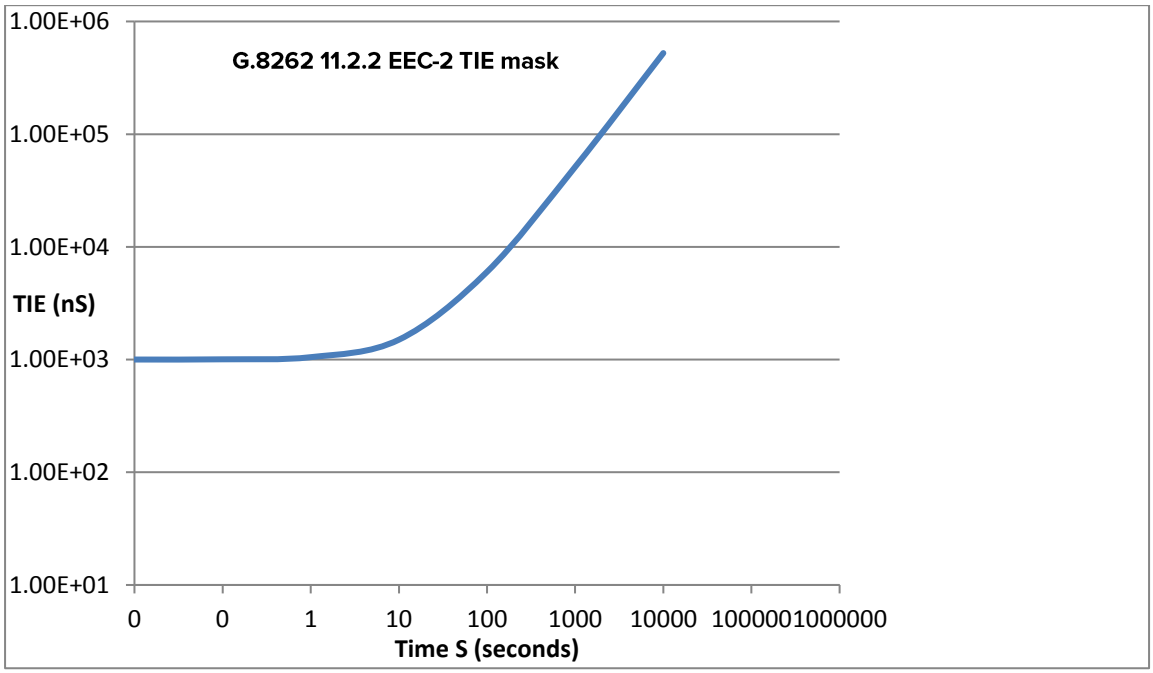
EEC-1

1. Set the ESMC being generated on Port 2 of the Paragon-100G to PRC. This will cause the DUT to lock to this signal and hence to the Synchronisation Source.
2. After allowing the DUT to settle, leave for at least 900s (15 minutes), then 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 also indicate PRC.
3. Restart the wander measurement and then set the ESMC on Port 2 to **DNU** (Do Not Use). This should cause the DUT to search for an alternative master clock signal to lock onto. If there are no other external signals then 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 further 10,000 seconds (approx. 3 hrs) minimum then stop the measurement.
5. The limits of operation are given by this mask reproduced from G.8262 Figure 13:



6. Check also that the TIE measurement shows a calculated frequency offset (shown at right side of TIE graph under Filters, Frequency Offset Removal) within ±4.6ppm.
7. **For EEC-2**, proceed as above, except the limit for TIE is as described in G.8262 11.2.2 and Table 14, illustrated here as a mask:



The limits for EEC-2 1st derivative TIE (fractional frequency offset) and 2nd derivative TIE (fractional frequency drift) are also specified in Table 14.

Currently it is not possible to compare results against the masks directly in Paragon-100G, but two methods of comparing results to G.8262 limits are available:

- Method 1: direct observation of results from the Paragon-100G (for EEC-1 and EEC-2 TIE), using marker functions.
- Method 2: export of Paragon-100G TIE results as a ***.csv*** file, with subsequent processing in Excel. This can be used for all cases, and is the only practical way to compute the 1st and 2nd differentials of TIE in the case of EEC-2.

On Paragon-100G, after running the TIE measurement, use ***FILE***, ***EXPORT*** from the pull down menus to create a ***.csv*** file, then open with Excel and perform the analysis.

Paragon-100G exported TIE files show the TIE values as a single series of integers based on 1ns units. To build a table of TIE versus time (S), compute the S values from the position in the series times the sampling interval selected (default is 0.033 333 320 seconds, corresponding to 30 samples/s) and the TIE values from the cumulative value of each series value minus 33333320. Compute derivatives using the central difference approximation **$dTIE/dS = (TIE_{(n+1)} - TIE_{(n-1)})/0.066666640$**. The constants used in the calculation need to be changed to match the original capture sample rate, if it is varied from its default 30/s.

See Calnex document CX5001e (on our website) as a practical example in Excel of the use of a Paragon exported TIE file, with central difference differentiation examples.

12. Appendix 1 - G.8262; Practical Interpretation Guidance

Frequency Accuracy (G.8262 Section 6)

	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	Free run	±4.6ppm	Recommend to test for an hour, longer if close to limits.
EEC Option 2	Holdover	±4.6ppm	Recommend to test for an hour, longer if close to limits.

Pull–in Range (G.8262 Section 7.1)

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

Hold–in Range (G.8262 Section 7.2)

	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	Not Applicable		
EEC Option 2	EEC is locked to the clock from the Paragon-100G. The frequency is then offset to ±4.6ppm.	EEC should remained locked at an offset at ±4.6ppm.	Lock can also be monitored by using ESMC (if supported).

Pull–out Range (G.8262 Section 7.3)

	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	EEC is locked to the clock from the Paragon-100G. The frequency is then offset until the EEC unlocks.	EEC should remain locked at an offset at ±4.6ppm but lock should extend beyond this.	G.8262 states this is for further study.
EEC Option 2	Not Applicable		

Wander Generation (G.8262 Section 8)

	Input Stimulus	Pass/Fail Criteria	Notes (G.8262 masks)
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	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	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	MTIE – Table 4, Figure 3 TDEV – Table 5, Figure 4

Jitter Generation (G.8262 Section 8.3)

	Input Stimulus	Pass/Fail Criteria	Notes
25G lanes (100GbE LR4)	• None, unless device requires packet stream to function.	Output Jitter ≤1.2UIpp in 60-second window, as G.8262 8.3, Table 6.	Measurement filter bandwidth: 20kHz to 200MHz as specified in G.8262 8.3, Table 6.
10G lanes (100GbE SR10, 40GbE)	• None, unless device requires packet stream to function.	Output Jitter ≤0.5UIpp in 60-second window, as G.8262 8.3, Table 6.	Measurement filter bandwidth: 20kHz to 80MHz as specified in G.8262 8.3, Table 6.

Wander Tolerance (G.8262 Section 9)

	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	• MTIE Wander Table 7, Figure 5 • TDEV Wander Table 8, Figure 6 • Sinusoidal Wander Table 9, Figure 7	The EEC is • Maintaining the clock within performance limits. • Not causing any alarms. • Not causing the clock to switch reference. • Not causing the clock to go into holdover.	To check whether the EEC is switching references or going into holdover, the Paragon can measure the wander and/or ESMC QL of the EEC output.
EEC Option 2	• TDEV Wander Table 10, Figure 8	The EEC is • Maintaining the clock within performance limits • Not causing any alarms. • Not causing the clock to switch reference. • Not causing the clock to go into holdover.	To check whether the EEC is switching references or going into holdover, the Paragon can measure the wander and/or ESMC QL of the EEC output.

Jitter Tolerance (G.8262 Section 9.2)

	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1 and **EEC Option 2**	• Test packet stream from Paragon-100G or thru-mode traffic. • Superimpose jitter to G.8262 9.2 Figure 9.	• The EEC does not drop packets for all jitter values presented. • The EEC does not Error/Alarm during the test for all jitter values presented. • The EEC does not go into Holdover during the test for all jitter values presented.	• Either as pass/fail with presented jitter values at the mask, or a margin test with jitter values above mask. • Allow settling time at each measurement point.

Wander Transfer (G.8262 Section 10)

	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	Not defined.	The phase gain of the EEC should be smaller than 0.2dB (2.3%).	There is no definition of the input stimulus to be used in G.8262. Without further guidance from the Standards, it is suggested that the amplitude and frequency values associated with mask points labelled f1, f2 and f3 on G.8262 Section 9.1.1, Table 9 and Figure 7 are used. Other values may be used as guided by the manufacturer.
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 13, Figure 11.	

Transient Response (G.8262 Section 11)

	Input Stimulus	Pass/Fail Criteria	Notes
EEC Option 1	EEC input reference is lost for 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 • Remove the cable between Port 2 and EEC
EEC Option 2	EEC input reference is lost for 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=DNU • Remove the cable between Port 2 and EEC

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