PRODUCT NOTE

CX4008

Analyzing PTP Networks

using the Paragon-X

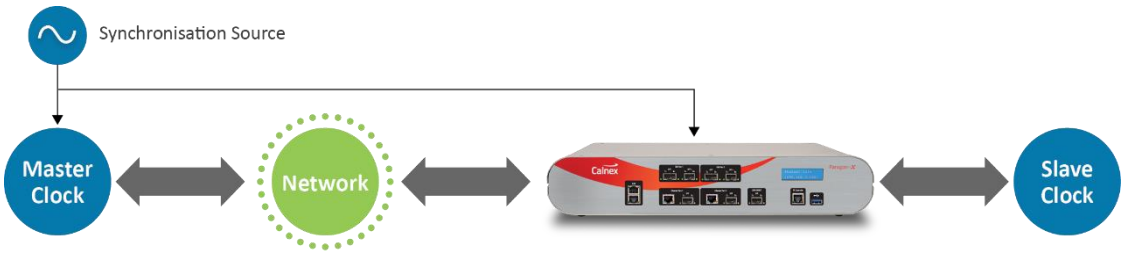
This document describes how to set up and use the Paragon-X to capture and analyze a bi-directional PTP (IEEE 1588v2) flow and the recovered frequency from a Slave Clock.

It explains how, by connecting Paragon-X next to a Slave Clock, the PDV from the Master Clock to Slave Clock, the PDV from Slave Clock to Master Clock, and various other PDV and inter-packet arrival time data can be used to analyze a PTP network.

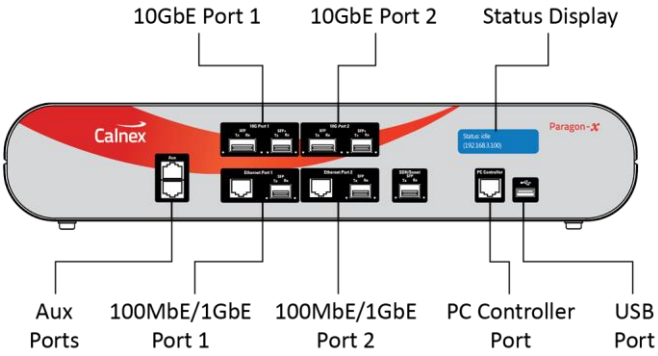
Also covered is how to use Paragon-X to apply impairments to PTP traffic, including the capture and replay of real PDV data to simulate a live environment in the laboratory.

Contents

1. Testing PTP



1.1 Connecting Paragon-X for Testing



The Paragon-X front panel provides the following interfaces:

- 100MbE electrical or optical (SGMII SFP)
- 1GbE electrical or optical (SFP) – with option 110 fitted
- 10GbE optical (XFP or SFP+) – with option 111 fitted

In earlier versions, the USB port is not enabled. In later versions, it can be used to supply power to the Option 133 External 1pps/ToD Frequency Converter accessory.

NOTE: When using optical connectivity, SFP/SFP+/XFP modules must be inserted into both ports on Paragon-X to enable their selection in the **Setup Interface - Ethernet** window in the Paragon-X Graphical User Interface (GUI)..

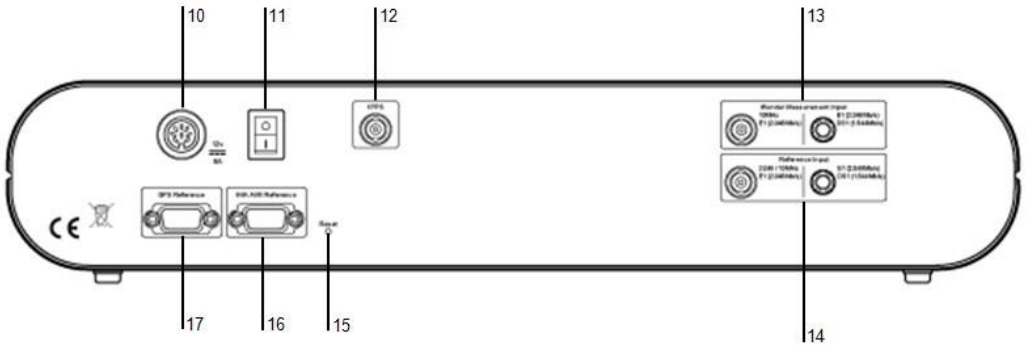
To enable measurement of the PTP performance of a device-under-test (DUT):

1. Connect the PTP Slave Clock port of the DUT to port 1 of Paragon-X
2. Connect the PTP Master Clock port of the DUT to port 2 of Paragon-X

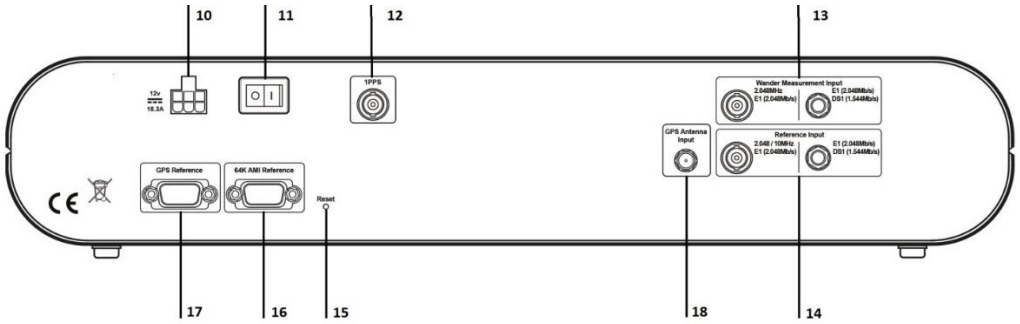
1.2 Connecting a Reference Clock to Paragon-X

The Paragon-X rear panel provides the following reference and measurement inputs:

Earler Versions



Later Versions



10 – DC Power Input
11 – Power Switch
12 – 1pps Reference Input
13 – Wander Measurement Inputs
- 2.048MHz (BNC)
- E1 (2.048Mb/s) balanced (Bantam) or unbalanced (BNC)
- DS1 (T1) (1.544Mb/s) balanced (Bantam)

14 – Reference Inputs
- 10MHz (BNC)
- 2.048MHz (BNC)
- E1 (2.048Mb/s) balanced (Bantam) or unbalanced (BNC)
- DS1 (T1) (1.544Mb/s) balanced (Bantam)

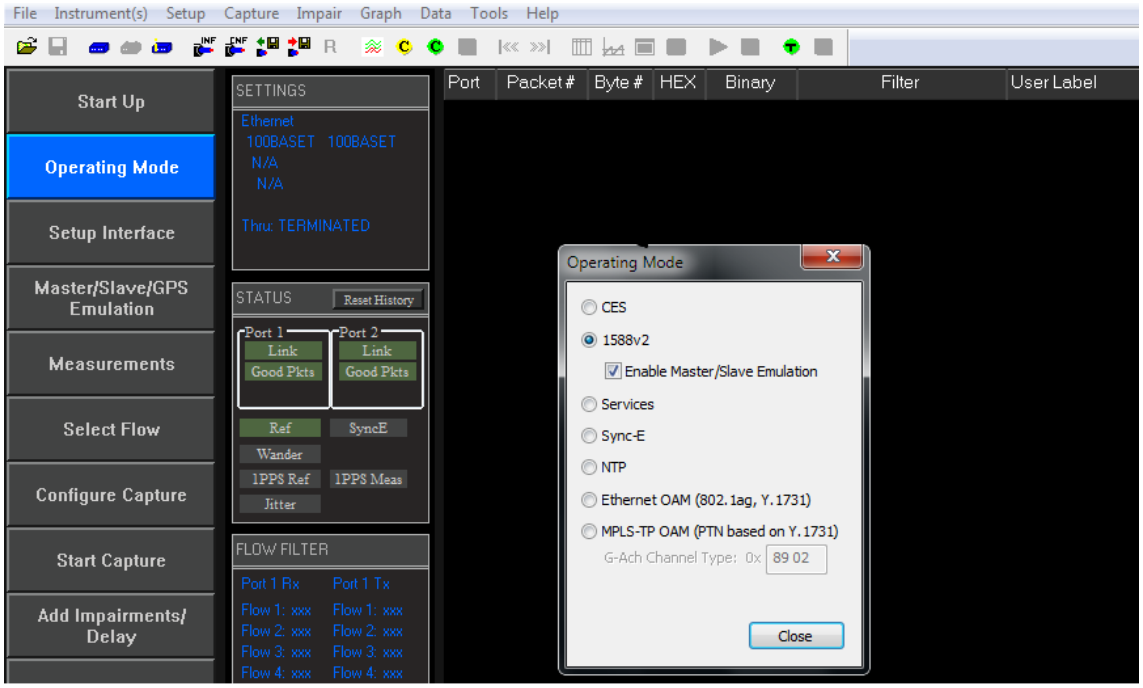
15 – Reset Switch
16 – 64K AMI Reference Input
17 – GPS Reference
18 – GPS Antenna Input (*currently unused)*

Connect the common synchronisation reference to the relevant reference input. If required, connect the common 1pps reference or Master Clock 1pps reference output to the appropriate Paragon-X 1pps reference input (12 or 17 depending on cable and connector type).

2. Application Setup

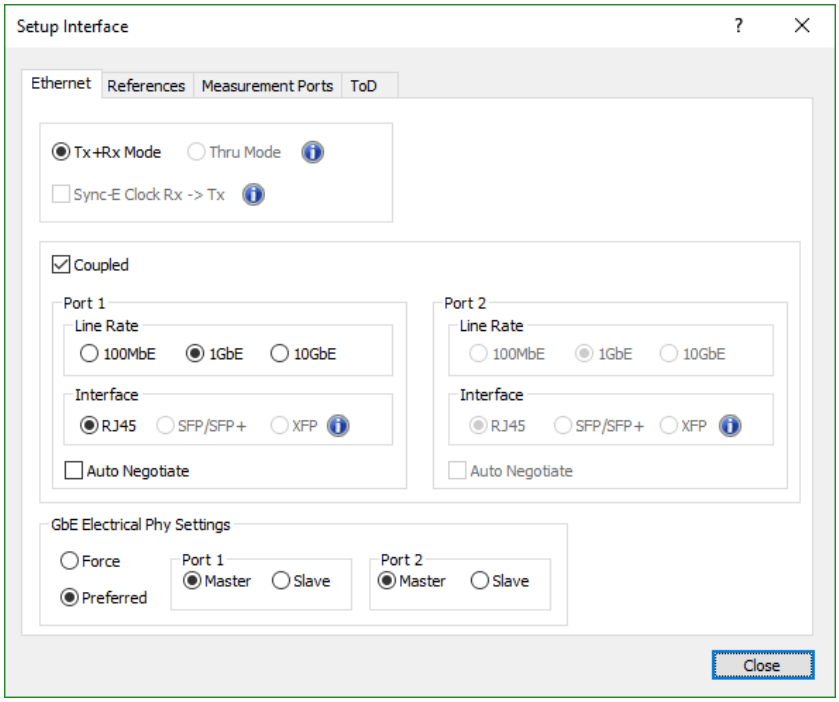
2.1 Configuring Paragon-X for PTP (1588v2) measurements

1. Verify that physical connections have been made as described above.
2. From your Windows PC, start the Paragon-X client (GUI) by clicking ***Start*** > ***All Programs*** > ***Calnex/Paragon-X*** (different Windows operating systems may vary slightly).
3. On the Paragon-X GUI, press ***Start Up*** and connect to the Paragon-X (see the *Getting Started Guide* for more details if required).
4. Click on the ***Operating Mode*** button then enable ***1588v2*** > ***Enable Master/Slave Emulation***.

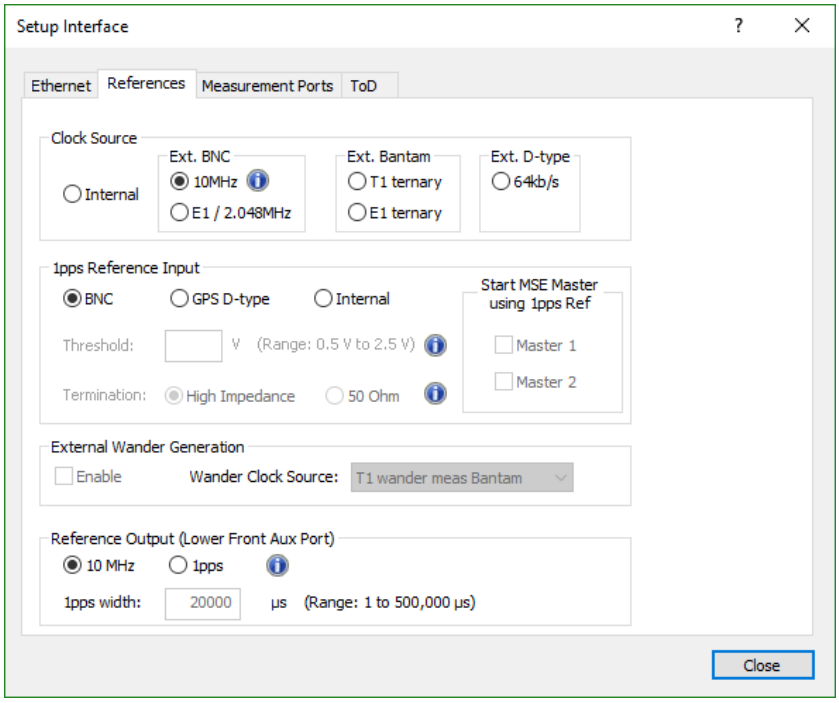


5. Select the ***Setup Interface*** button nd ensure the appropriate line rate and interface are configured.

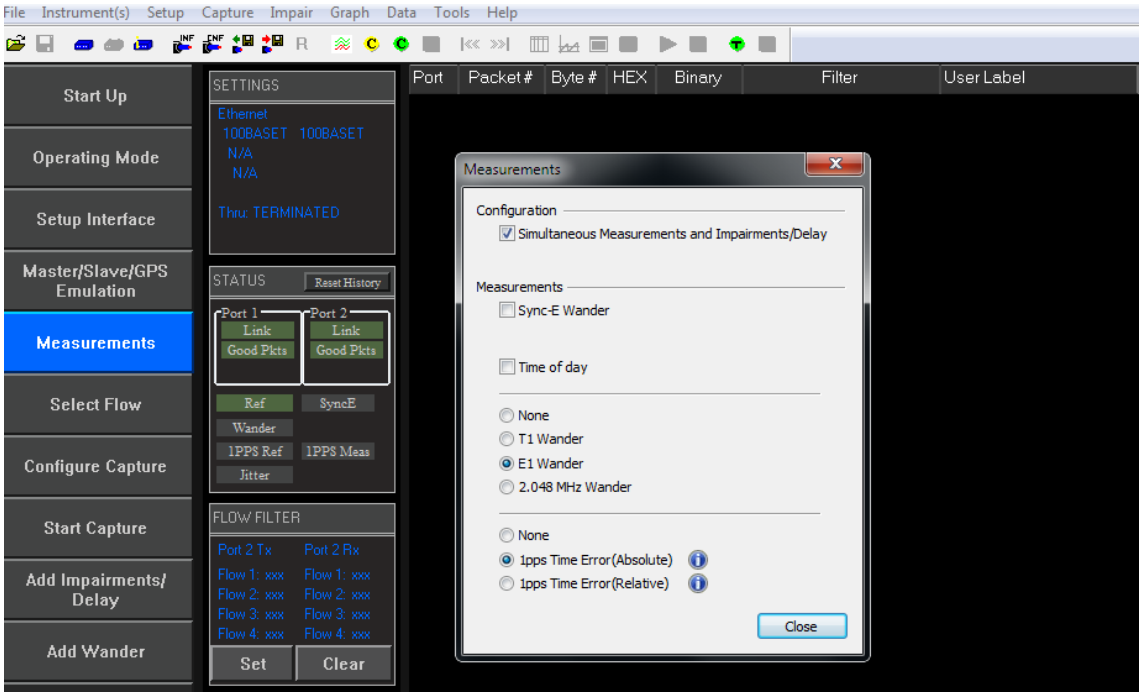
   Note: if using SFP, SFP+ or XFP modules, the transceivers must be inserted into both Ports 1 and 2 of Paragon-X to allow their selection.



6. Select the **References** tab, then configure the appropriate reference sources e.g.

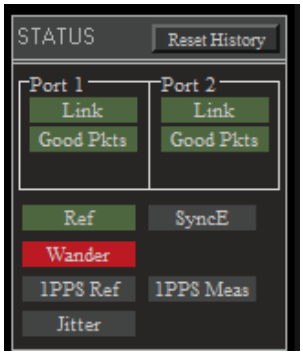


7. If measuring recovered frequency, select the ***Measurements*** button then select the appropriate measurement e.g.



8. Click on the **Close** button.

9. Check **Port 1** and **Port 2 Link** and **Good Pkts**, **Ref** lock and **Wander** Lock (if carrying out a E1/T1/2.048MHz wander measurement) are showing as green. Wander is red in the example below to indicate no Wander measurement signal is detected.

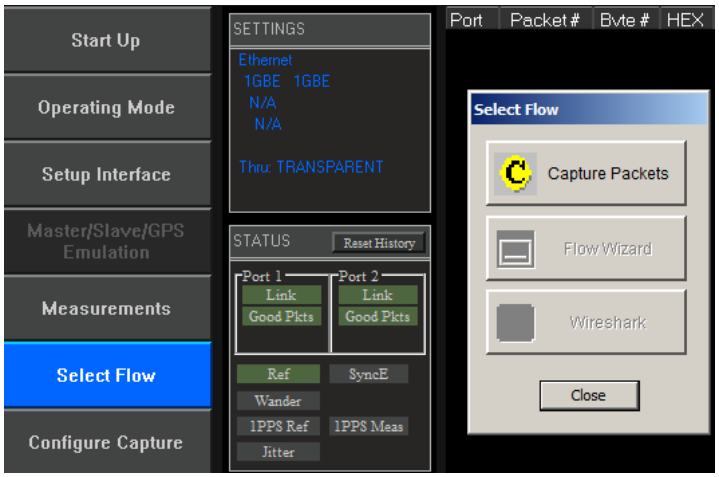


Yellow indicators mean that a status has changed from bad to good, so if any are yellow, click Reset History and confirm they go green.

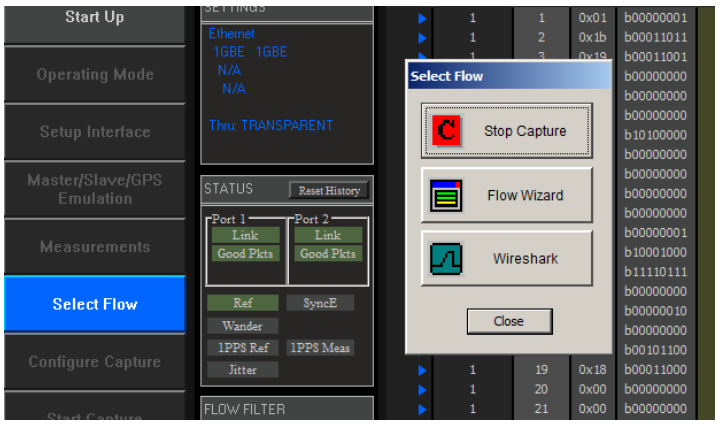
2.2 Setting Filters to Capture/Replay the 1588v2 Flow

The Paragon-X uses a tool called “Flow Wizard” to select the 1588v2 flows and set the filters to target these flows.

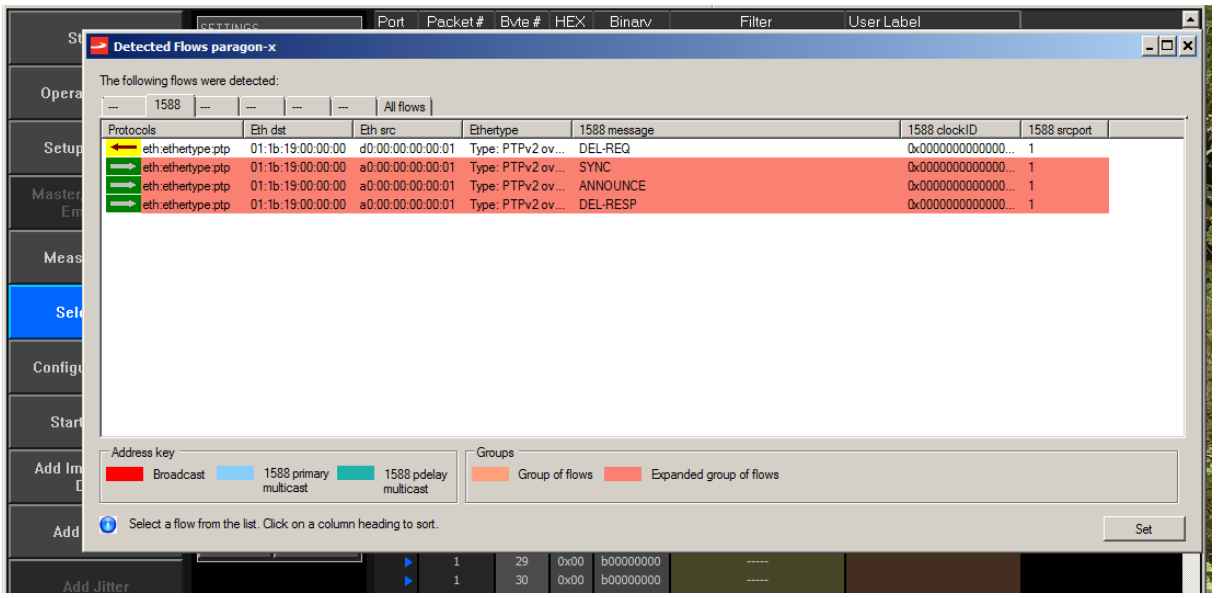
1. Click on ***Select Flow*** and the following window will appear:



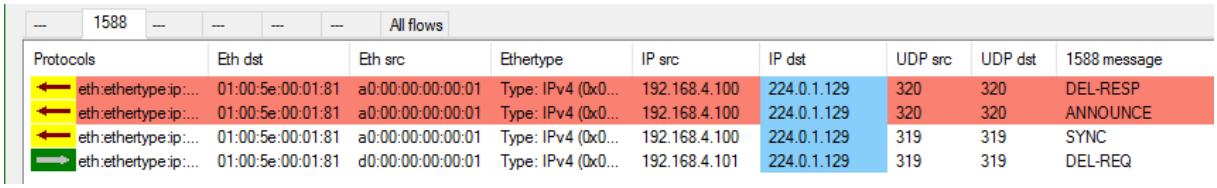
2. Click on the ***Capture Packets*** button to start the capture.
3. After a short time (approximately 10 Seconds) click on the ***Stop Capture*** button.



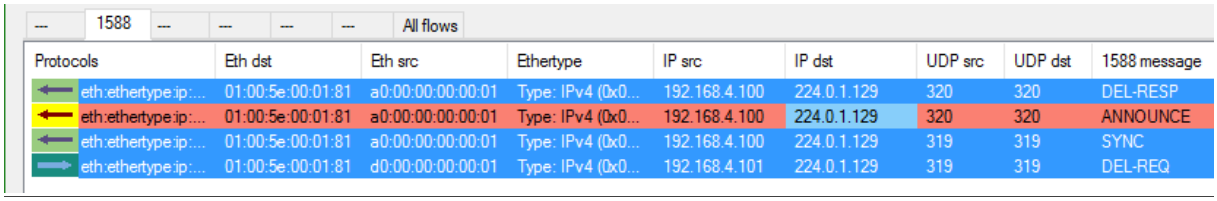
4. Click on ***Flow Wizard*** and the following screen is displayed:



5. Flow Wizard will automatically group flows that have the same value for each of the fields displayed. To show the individual messages, right click on a pink row and then click ***"Expand row to show individual message types".***



6. Select the flows of interest. Multiple flows can be selected by using either the "Shift" and left mouse button or "Ctrl" and left mouse button. For example, to select **SYNC**, **DEL-RESP** and **DEL-REQ** messages, select the first message row then Ctrl-click the second and third message rows. All the messages selected will be highlighted in blue, as shown below.



7. Click 

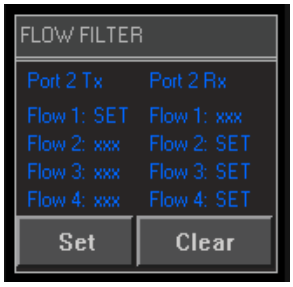
to set the Filters and then 

to close the window.

8. Click 

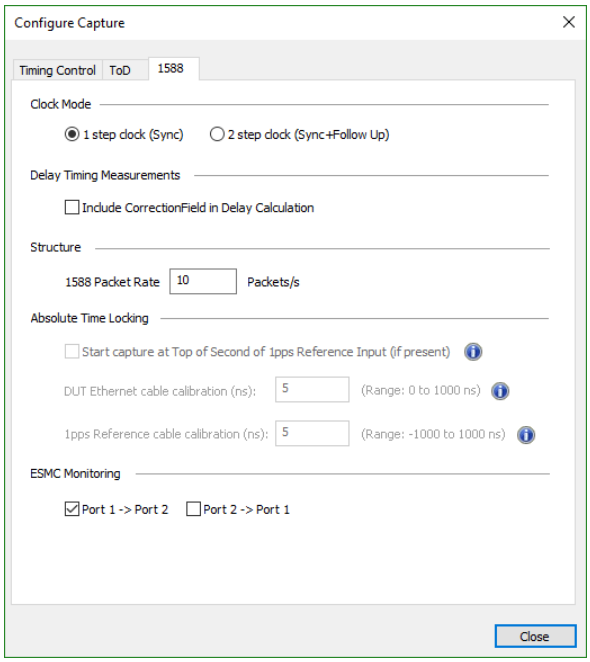
to close the **Select Flow** window.

9. The **Flow Filter** window in the main Paragon-X GUI will now show that filters have been set.



2.3 Settings for IEEE1588

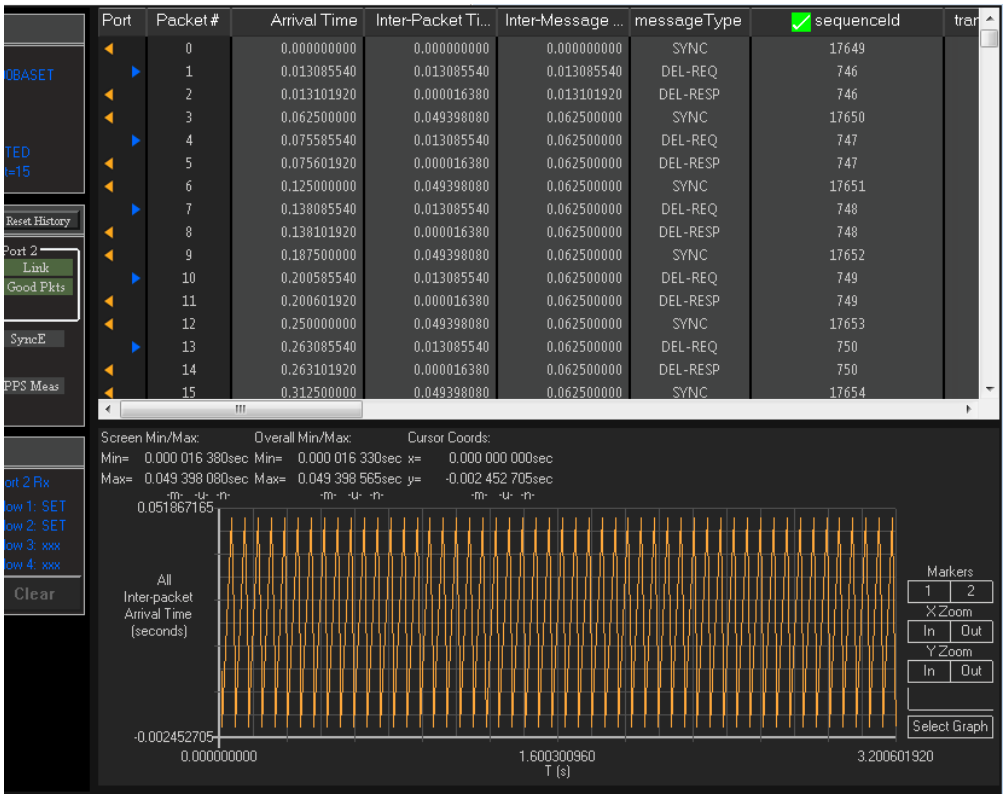
1. Click on the ***Configure Capture*** button then select the 1588 tab:



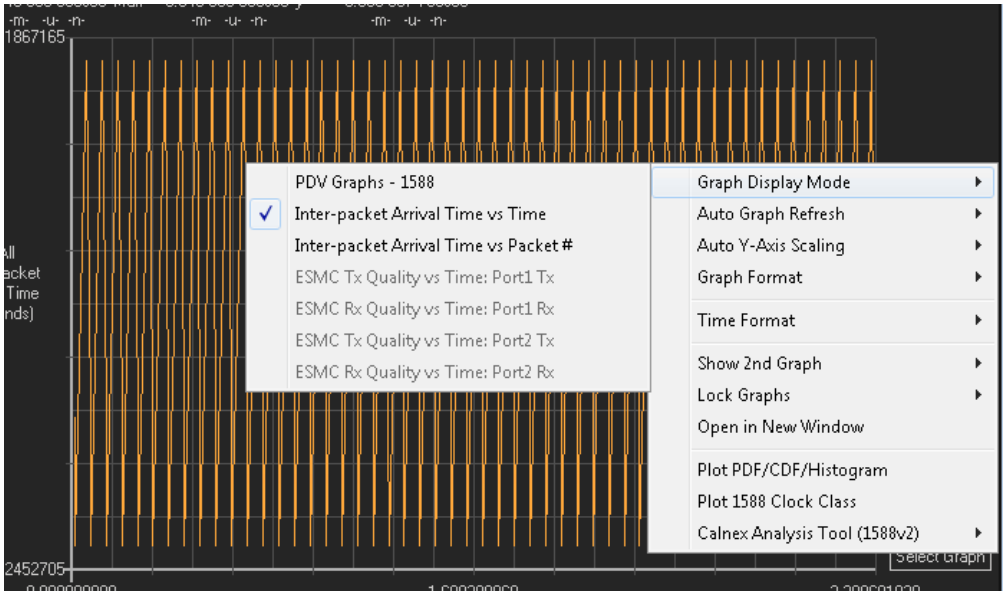
2. Select either **1 step clock (Sync)** or **2 step clock (Sync + Follow_Up)** mode depending on the DUT mode to be tested.
3. Tick the box if the **CorrectionField** value contained in the **Sync** message is to be included in the calculation of the captured PDV.
4. Enter the 1588 Packet rate. This is used if captured data is exported to Microsemi TimeMonitor.

2.4 Capturing IEEE1588 Header and Timing Information

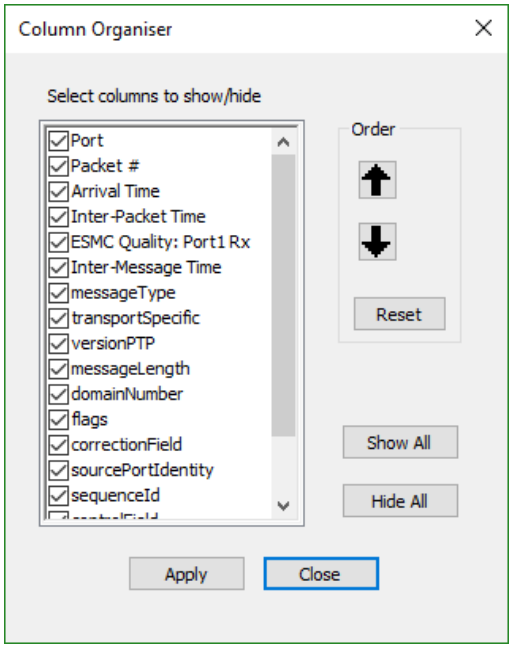
1. Click on the ***Start Capture*** button. The Timing Header and directional information for each message will be displayed in the table and the graph will show the combined inter-packet arrival time. The table continues to update in real-time with the captured bi-directional 1588v2 messages.



2. The graph can show 1588, SyncE or E1/T1 data (as available depending on test configuration). The displayed data can be selected by using the Select Graph option at the bottom right corner of the graph to display a menu of options:



3. Click on the ***Stop Capture*** button to stop the capture.
4. By default the Paragon shows all the fields in a 1588 message header. By using the **Data – Column Organiser** menu option, it is possible to display only those of interest by ticking or unticking each option:



3. Analyzing an IEEE1588 Capture

Paragon-X offers a number of ways to evaluate captured data. This section gives a brief introduction and explanation of some of these methods.

3.1 Analysing for mis-ordered, missing and repeated messages

1. The header and timing table allows the user to quickly determine if there are any mis-ordered, missing or repeated packets. An icon at the top of the **SequenceID** column will indicate this:

   Indicates no error

   Indicates an error has occurred

2. To view to the first/next error use the  icon in the menu bar, and the first/next error row will be displayed at the top of the table. Errors are identified by the following 1588 message row being highlighted in red, so it may be be necessary to scroll up to determine the missing row.

   In the screenshot below the **DEL-REQ** with **sequenceId** 706 has no corresponding **DEL-RESP** message from the Master Clock. The next **DEL-RESP** message (with **sequenceId** 707) is highlighted in red to show the previous one is missing.

425	12.875000000	0.062471090	0.062500000	DEL-REQ	0x0	0x0000000000000000	705
426	12.875017070	0.000017070	0.062488160	DEL-RESP	0x0	0x0000000000000000	705
427	12.937500000	0.062482930	0.062500000	DEL-REQ	0x0	0x0000000000000000	706
428	13.000000000	0.062500000	0.062500000	DEL-REQ	0x0	0x0000000000000000	707
429	13.000017070	0.000017070	0.125000000	DEL-RESP	0x0	0x0000000000000000	707
430	13.062500000	0.062482930	0.062500000	DEL-REQ	0x0	0x0000000000000000	708
431	13.062517070	0.000017070	0.062500000	DEL-RESP	0x0	0x0000000000000000	708

   Note: The number of columns displayed in this image has been reduced from the default for clarity by using the Column Organiser option described in point (4) of the previous section.

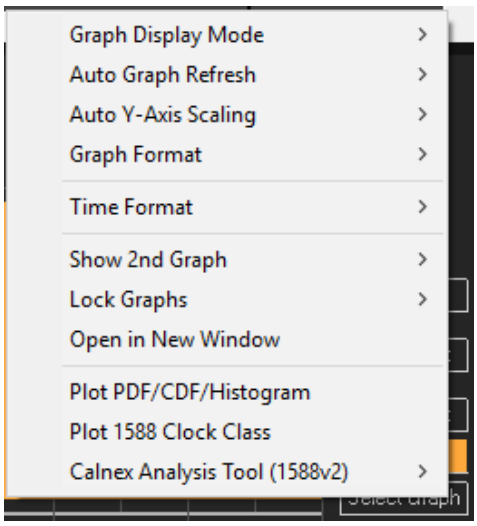
3. To view the previous error use the  icon.

3.2 Analysing captured messages by using the graphs

Paragon-X offers extensive graphing facilities to analyse the 1588 Master Clock – Slave Clock timing

1. To access the graph options click 

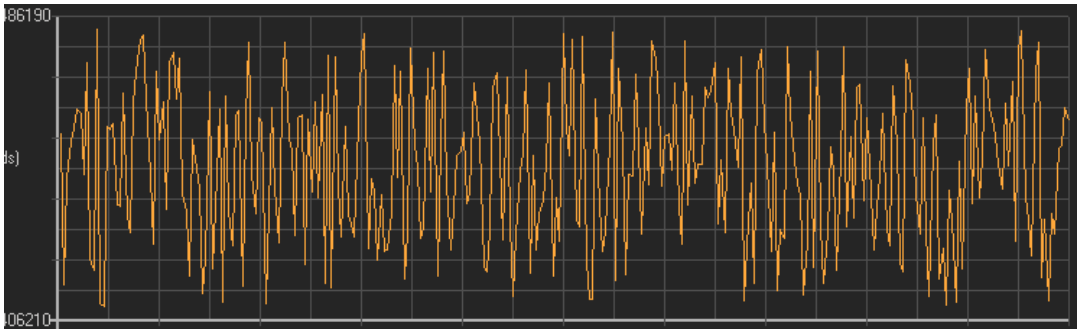
   to display a menu:

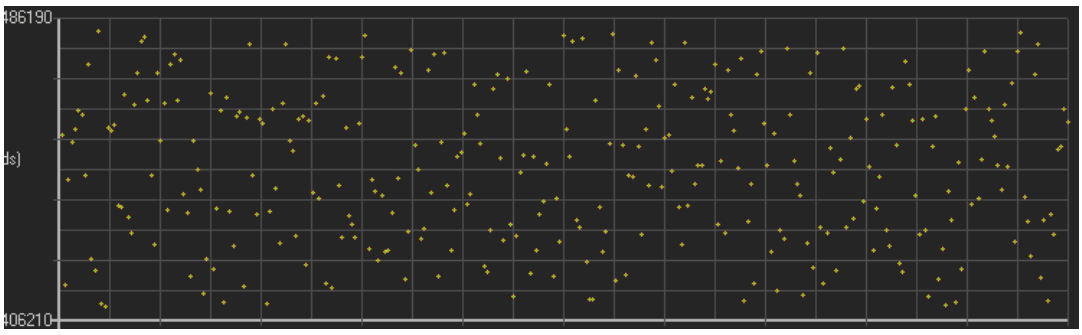


- **Graph Display Mode** – Access to the different graphs for analysis:

Menu option	Description
PDV Graphs – 1588	• Sync PDV • Slave Wander • Pdelay_Req PDV • Pdelay_Resp PDV • Follow_Up PDV • Delay_Resp RTD • Delay_Req PDV • Round Trip PDV
Inter-packet Arrival Time vs Time	Displays the Inter-packet arrival time for a specific message against time. • Sync • Delay_Req • Pdelay_Req • Pdelay_Resp • Follow_Up • Delay_Resp
Inter-packet Arrival Time vs Packet #	Displays the Inter-packet arrival time against packet number.

- **Auto Graph Refresh** – Graph refreshes approximately every 10 seconds.
- **Graph Format** – Choose between line or dot graph format (upper and lower images, respectively):





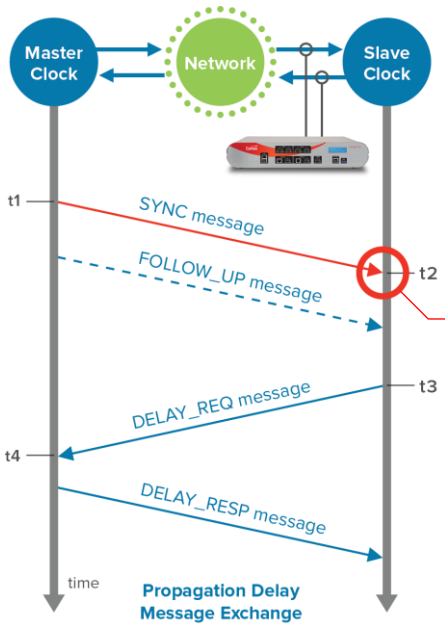
- **Show 2nd Graph** – A second graph is displayed of the same data which can be configured independently of the first.
- **Lock Graphs** – If two graphs are displayed and showing the same data, selecting On links their x-axis so that both are aligned.
- **Open in New Window** – Opens another graph in a new window which can be configured independently of any others.

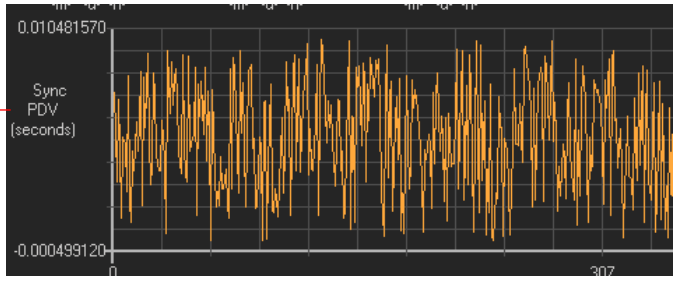
3.3 Description of PDV graphs

A description of each graph with examples is provided on the following pages. Note that all PDV graphs show the *variation between values* and not absolute values, and Paragon-X must be situated next to the Slave Clock and locked to the Master Clock's clock reference.

Sync PDV (1 step)

The Paragon-X uses the arrival time of the Sync message at the Paragon-X and the timestamp from the Sync message to calculate Sync PDV.

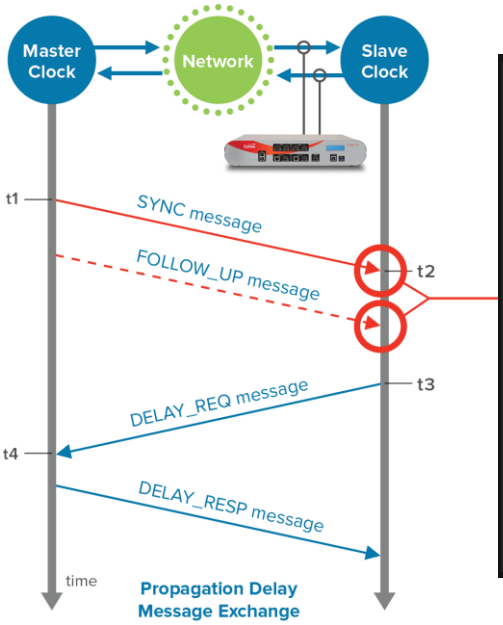


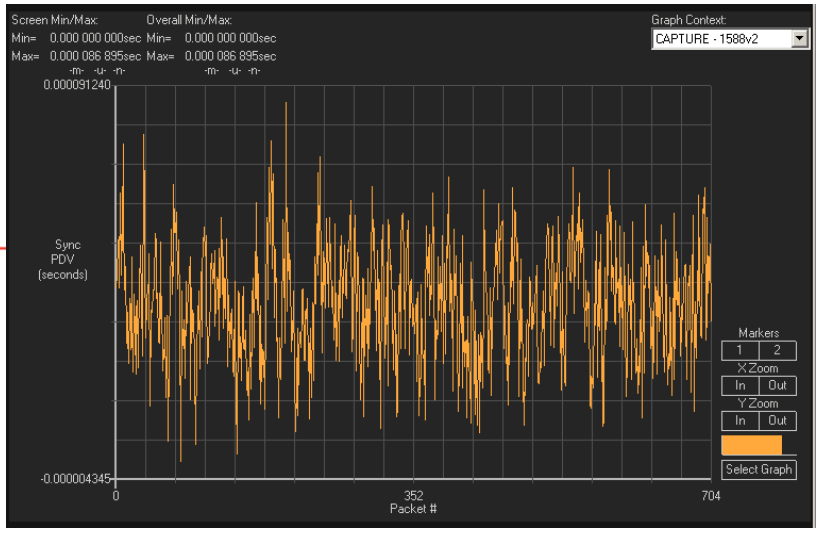


Sync PDV – Example of a Live Capture

Sync PDV (2 step)

The Paragon-X uses the arrival time of the Sync message at the Paragon-X and the timestamp from the Follow-Up message to calculate Sync PDV. Note: ***2 step clock*** needs to be selected in the 1588 Settings as previously described.

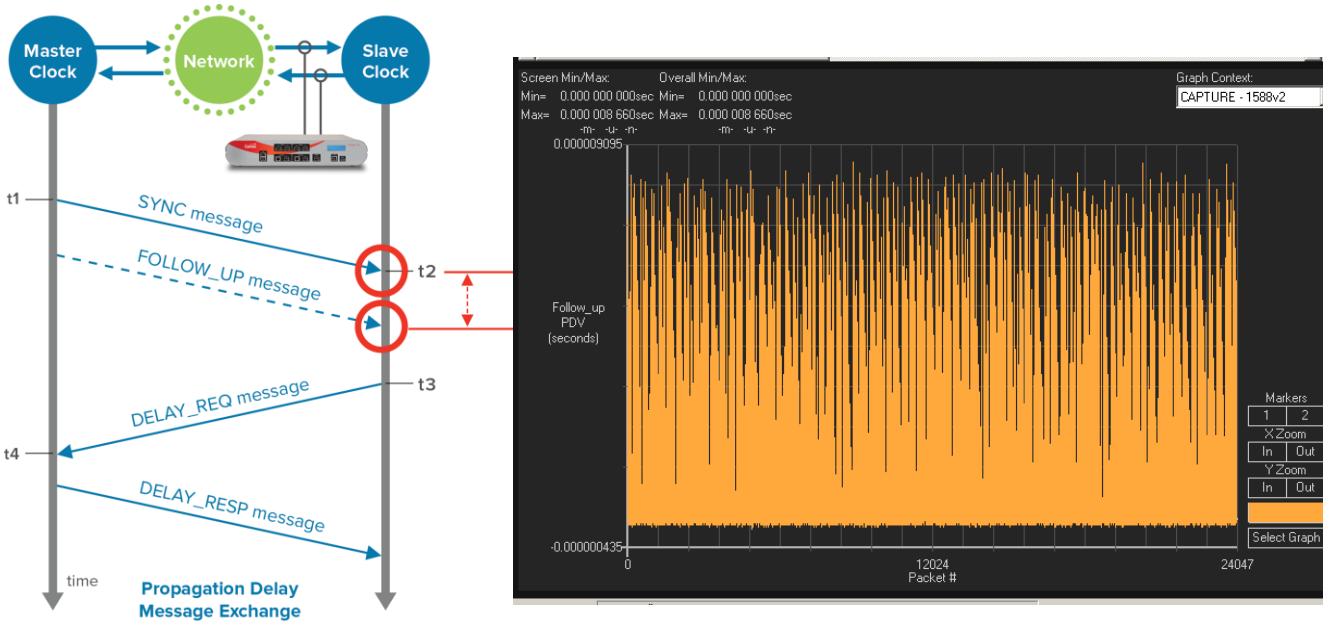




Sync PDV – Example of a Live Capture

Follow_Up PDV

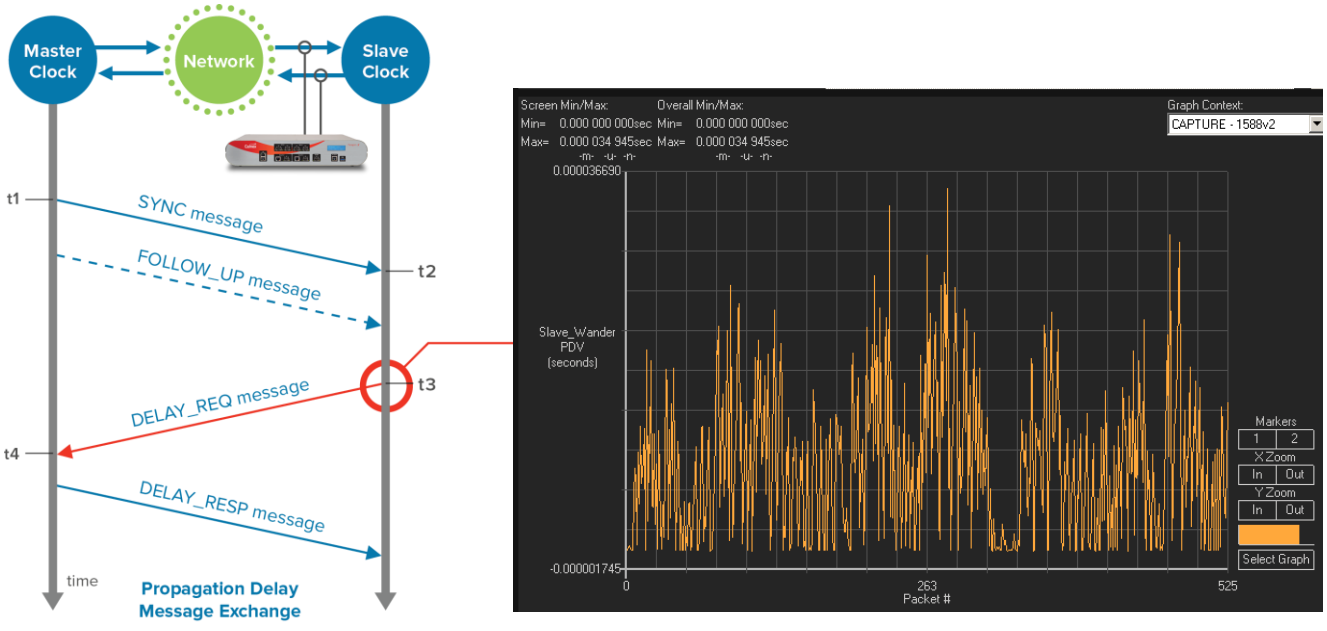
The Paragon-X graphs the variation in arrival time of the Follow_Up message with respect to the Sync message as shown below:



Follow_Up PDV – Example of a Live Capture

Slave Clock Wander

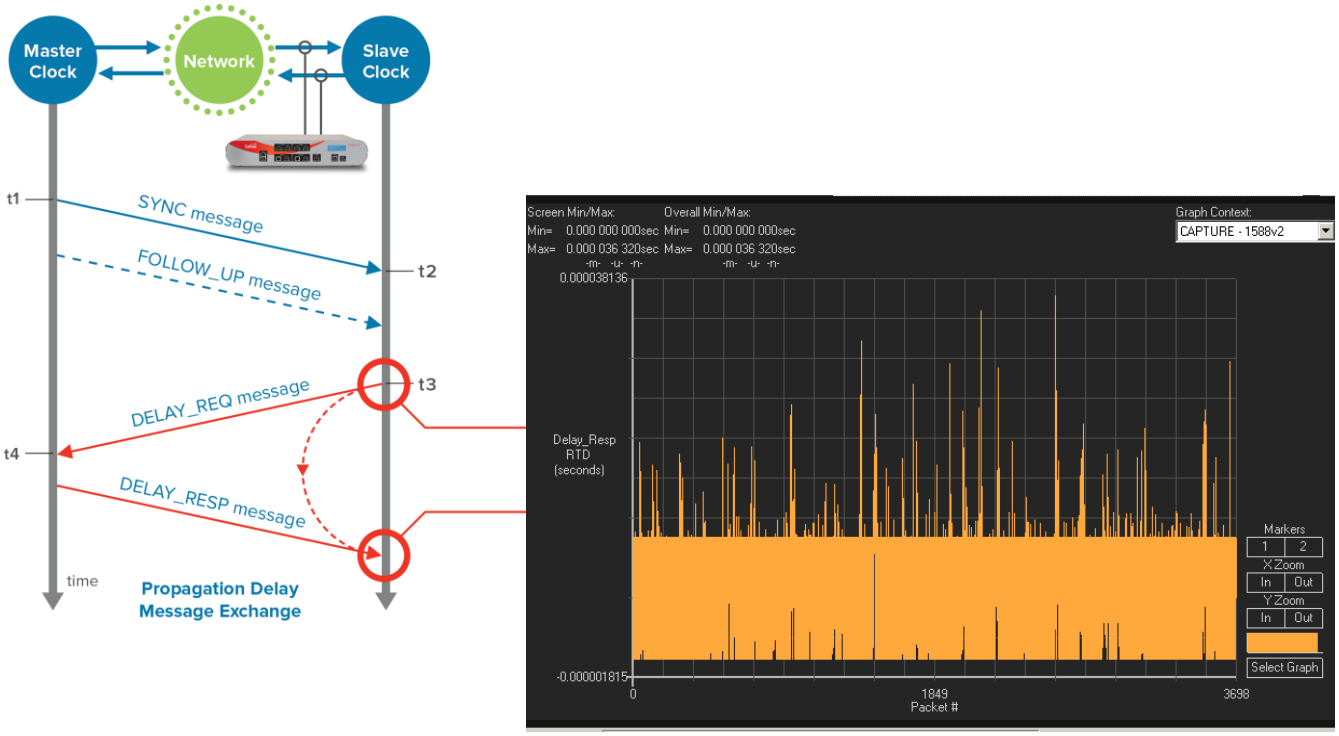
The Paragon-X extracts the embedded timestamp within the Delay_Req message and compares it to the Master Reference, the variation is then graphed to provide the Slave Wander output as shown below:



Slave Wander – Example of a Live Capture

Delay_Resp Round Trip Delay (RTD)

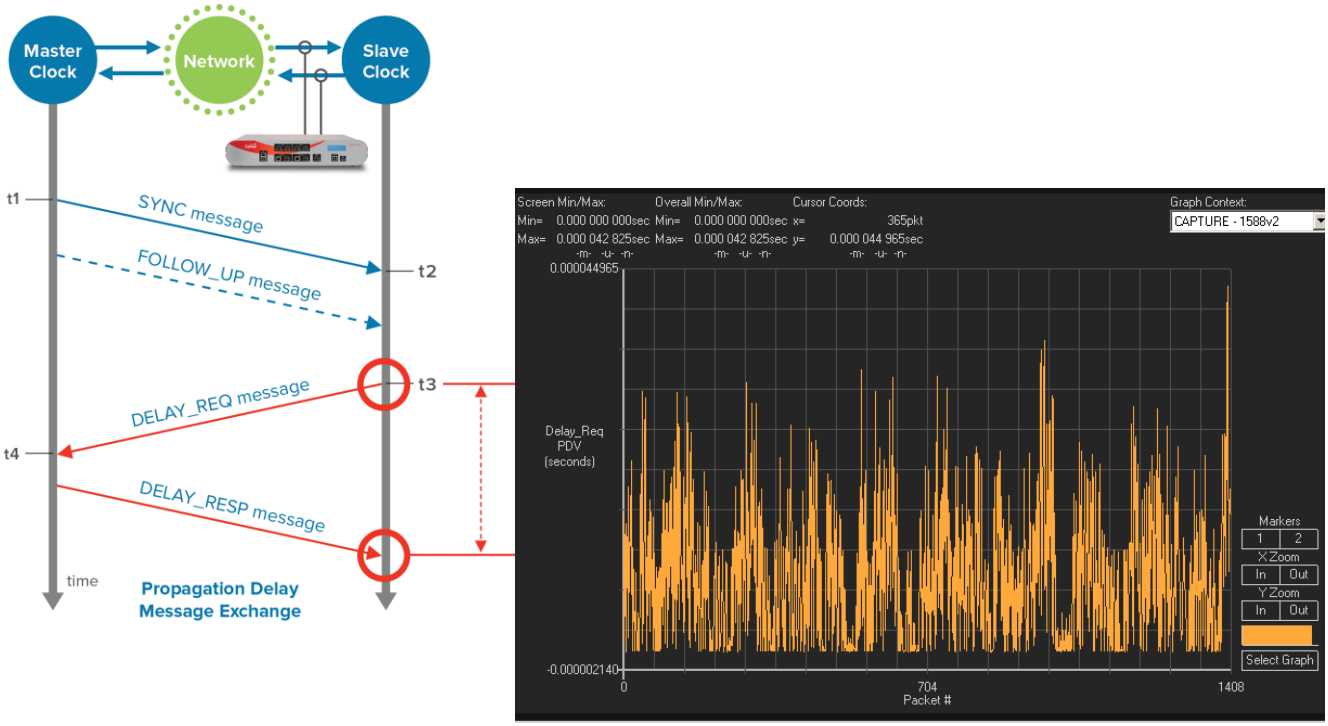
The Paragon-X calculates and graphs the time difference between the arrival time of the Delay_Req message and the corresponding Delay_Resp message as shown below:



Delay_Resp Round Trip Delay (RTD) – Example of a Live Capture

Delay_Req PDV

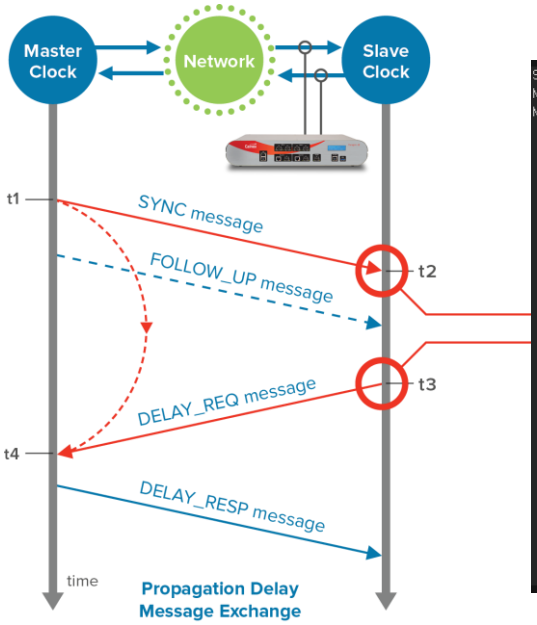
The Paragon graphs the variation between the launch time (arrival time at the Paragon) of the Delay_Req message and the embedded timestamp, t4, in the Delay_Resp message as shown below:

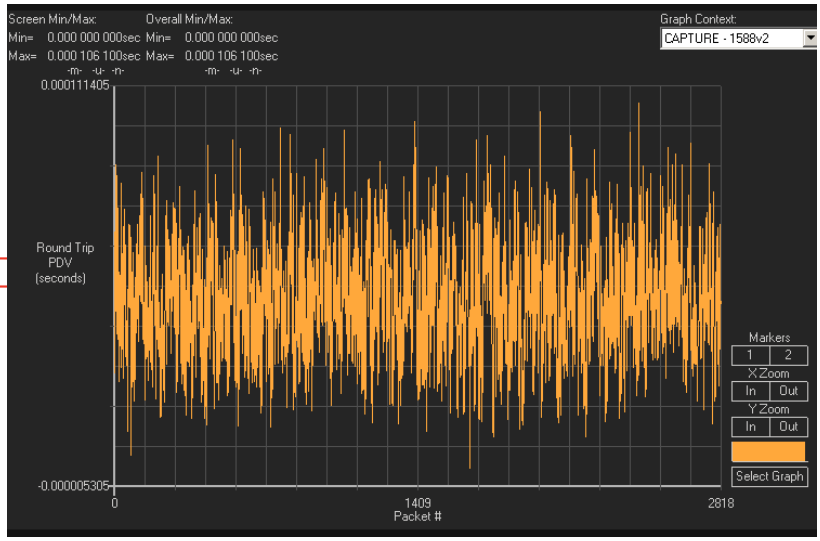


Delay_Req PDV – Example of a Live Capture

Round Trip Delay

The Paragon graphs the variation in (t2 – t1) + (t4 – t3) Round Trip Delay i.e. the calculation performed by the Slave as shown below:



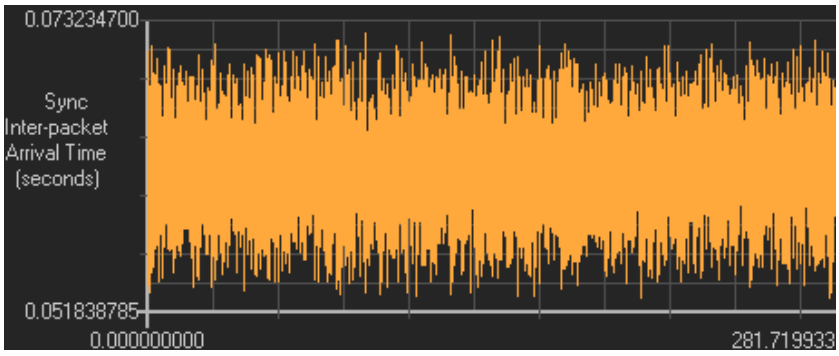


Round Trip Delay – Example of a Live Capture

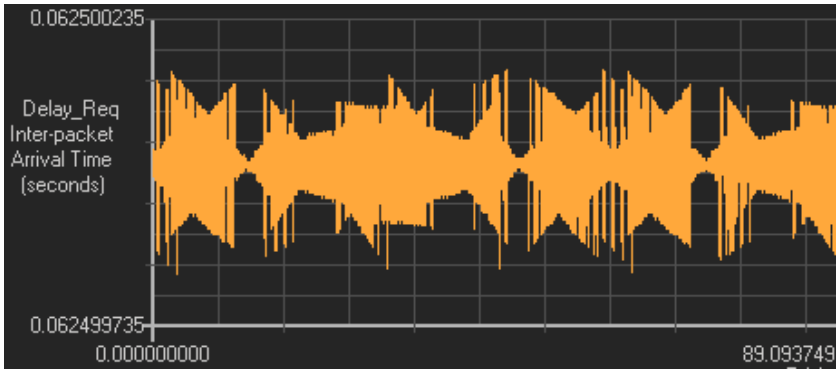
3.4 Description of Inter-packet Arrival Time vs Time Graphs

For each of the 1588 messages it is possible to graph the Inter-packet arrival time versus time. This will allow you to have enhanced visibility of the 1588 network by determining if the messages are arriving at regular intervals and/or if they are being delayed by the network, Master Clock or Slave Clock.

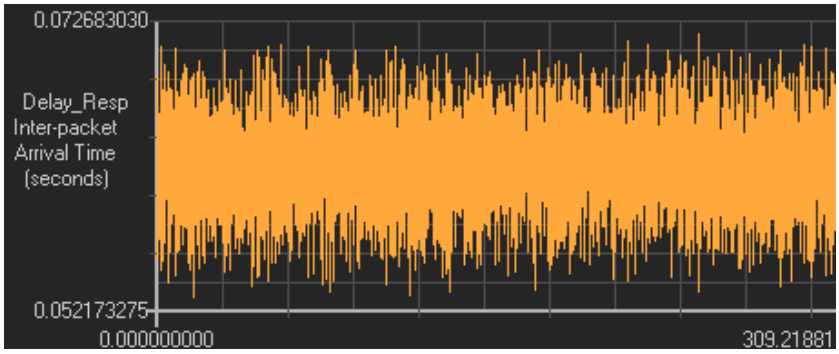
Sync IPG



Delay_Req IPG



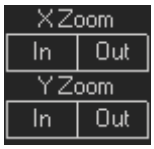
Delay_Resp IPG



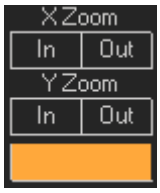
3.5 Using the Graph Zoom function

1. To zoom into a particular part of the graph, click and drag with the left mouse button to highlight the desired area. When the button is released the display will zoom in to the highlighted section. Clicking on the graph area with the left mouse button also zooms in, with the displayed view centred around the click location.

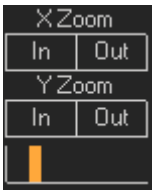
2. It is also possible to zoom the graph in both the X- and Y- axis around the graph centre by using the buttons.



3. A zoom indicator to the right of the graph indicates the portion of data currently being displayed:



The full capture
is being displayed

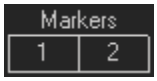


A partial view
of the full capture
is being displayed

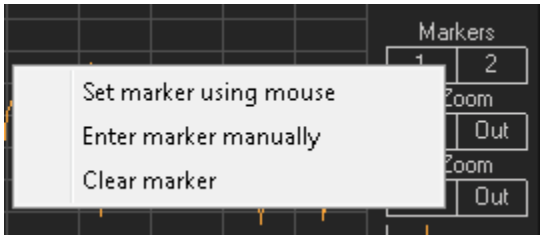
4. To zoom out, click the displayed graph area using the right mouse button.

3.6 Using the Graph Marker function

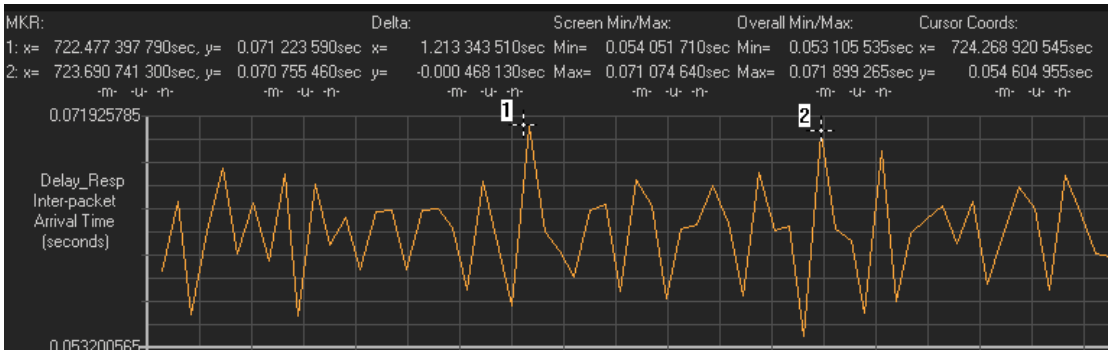
1. There are two markers that can be accessed from buttons:



These allow measurement on the graph by either using the mouse to click on the graph directly or by manually entering values.



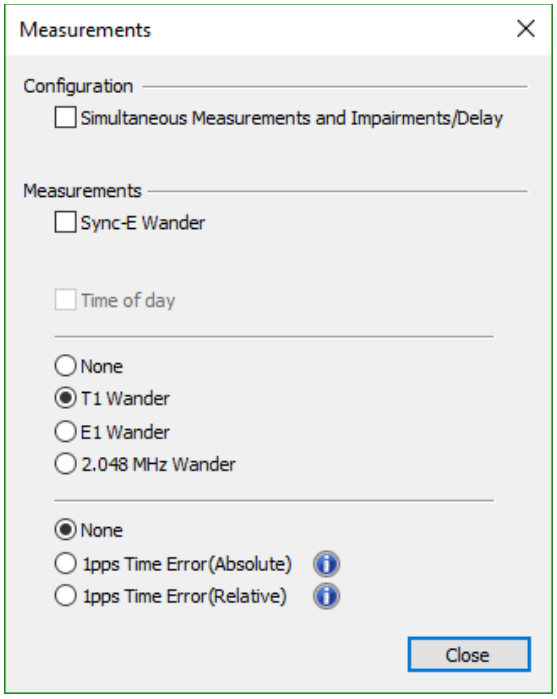
2. Data relating to the placed markers and displayed data is shown at the top of the graph:



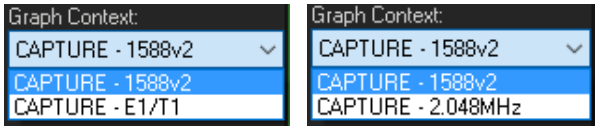
3. <Ctrl>-click left mouse button on a packet within the graph will bring that packet to the top of the table above the graph, allowing inspection of its properties.

3.7 Analysing E1/2.048MHz/T1 wander from the recovered clock

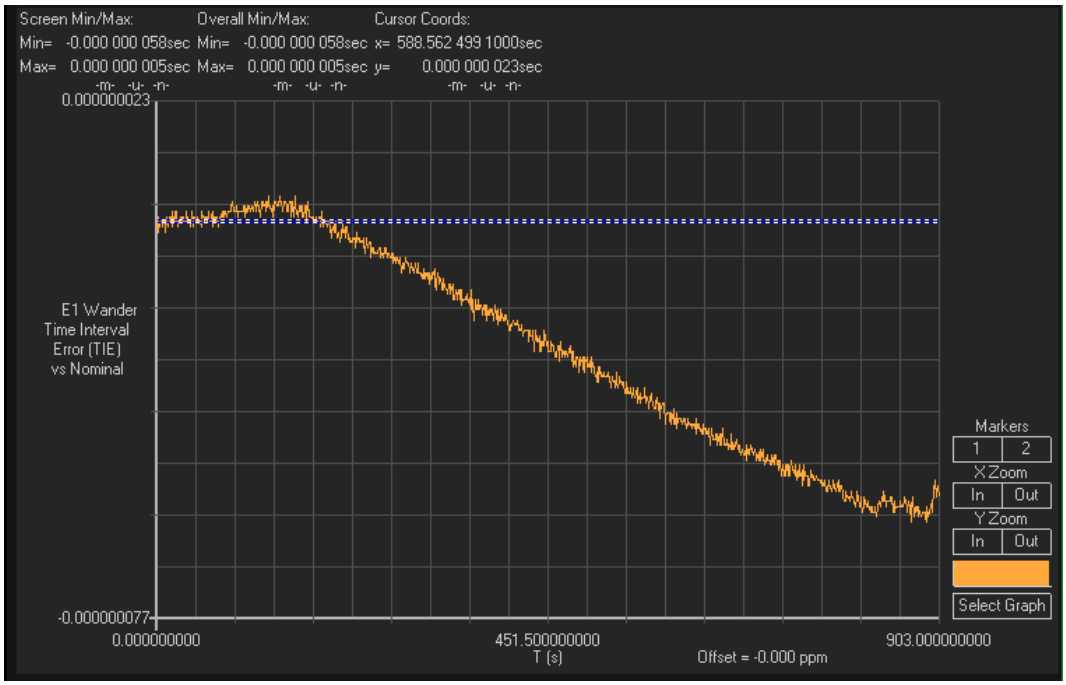
1. If measurement of T1, E1 or 2.048MHz wander has been selected from the **Measurements** dialog, it is possible to view the results in the displayed graph.



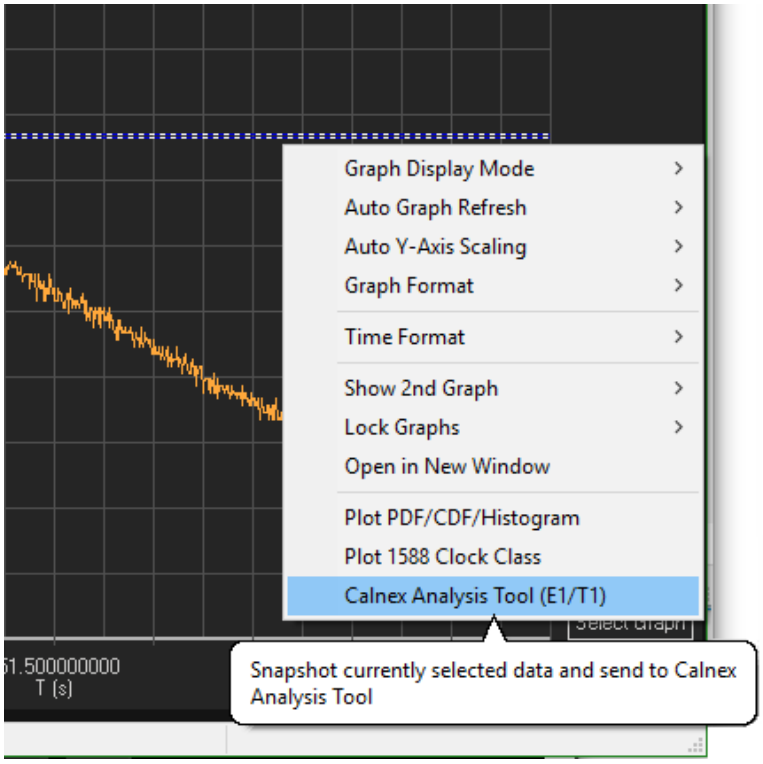
2. Select the desired capture from the **Graph Context** dropdown menu at the top right side of the graph area. Note that only the option selected in the **Measurements** dialog will be available for selection:



3. The E1/T1/2.048MHZ wander TIE graph will then be displayed:



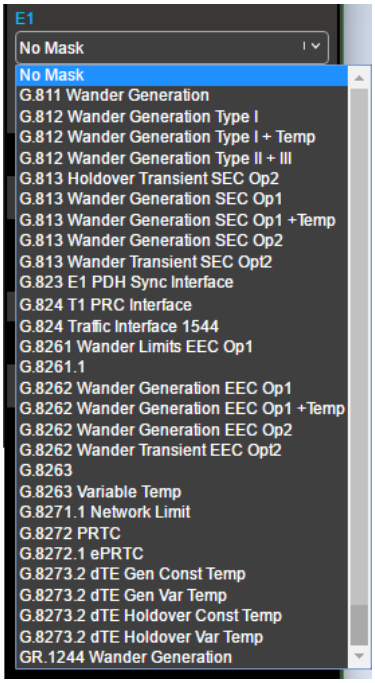
4. To measure against the MTIE/TDEV limit lines, click Select Graph and then **Calnex Analysis Tool (E1/T1)**.



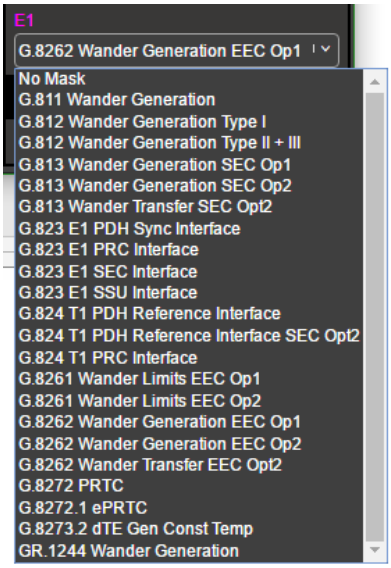
This will launch the Calnex Analysis Tool (CAT) which can be used to further analyse the captured data:

MTIE/TDEV masks can be viewed and selected from the Masks menu for each measurement type e.g.

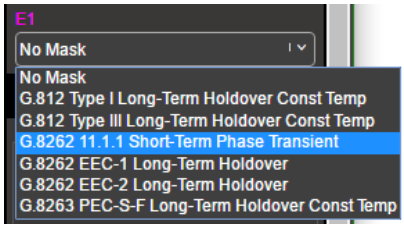
E1 MTIE mask menu



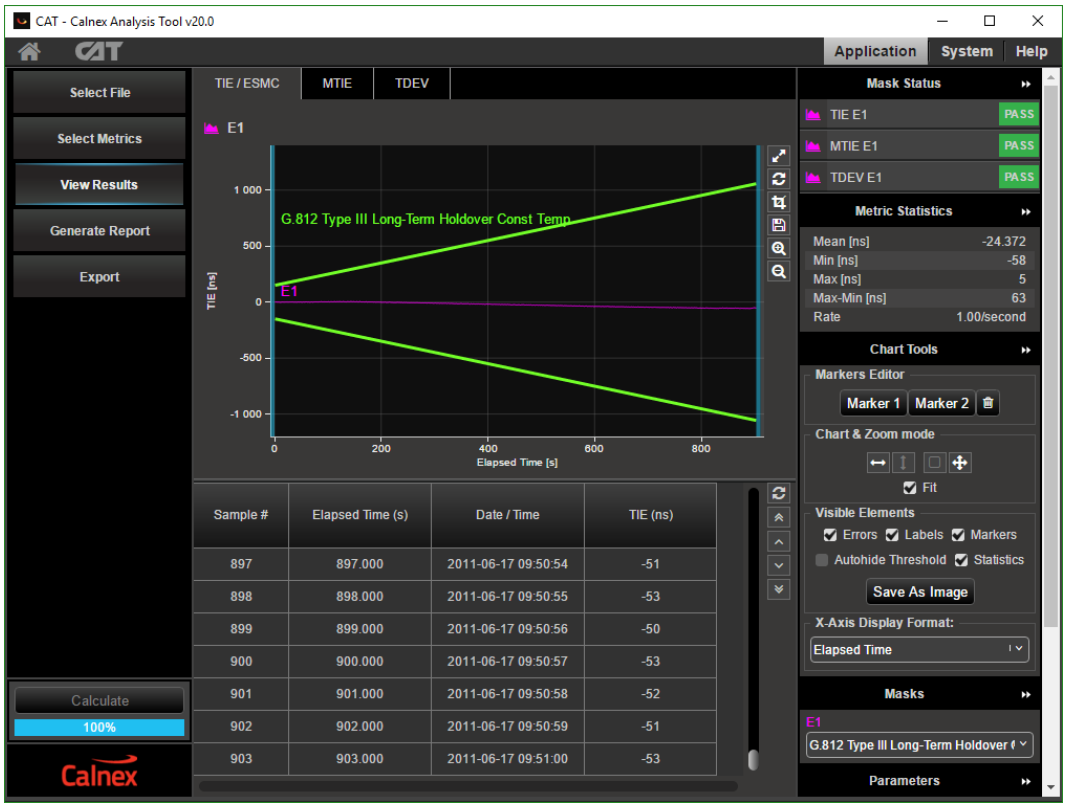
E1 TDEV mask menu

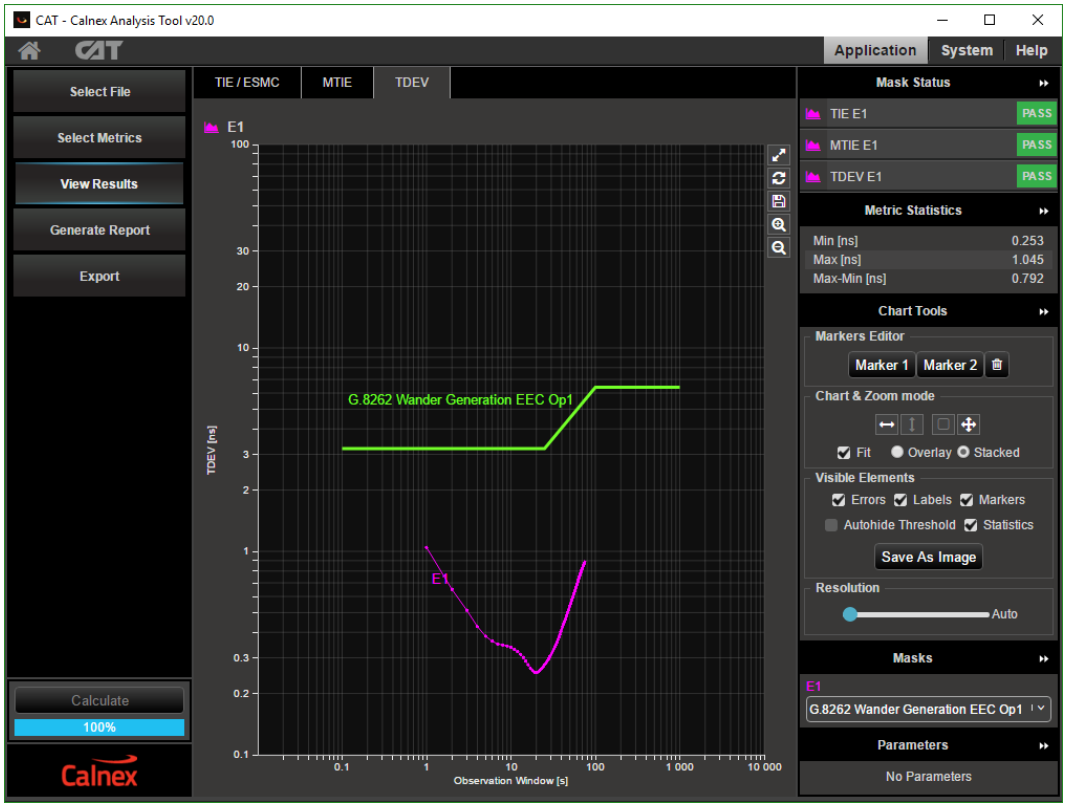


E1 TIE analysis



Paragon-X will then analyse the MTIE and TDEV data against the relevant masks and display a Pass/Fail indication.

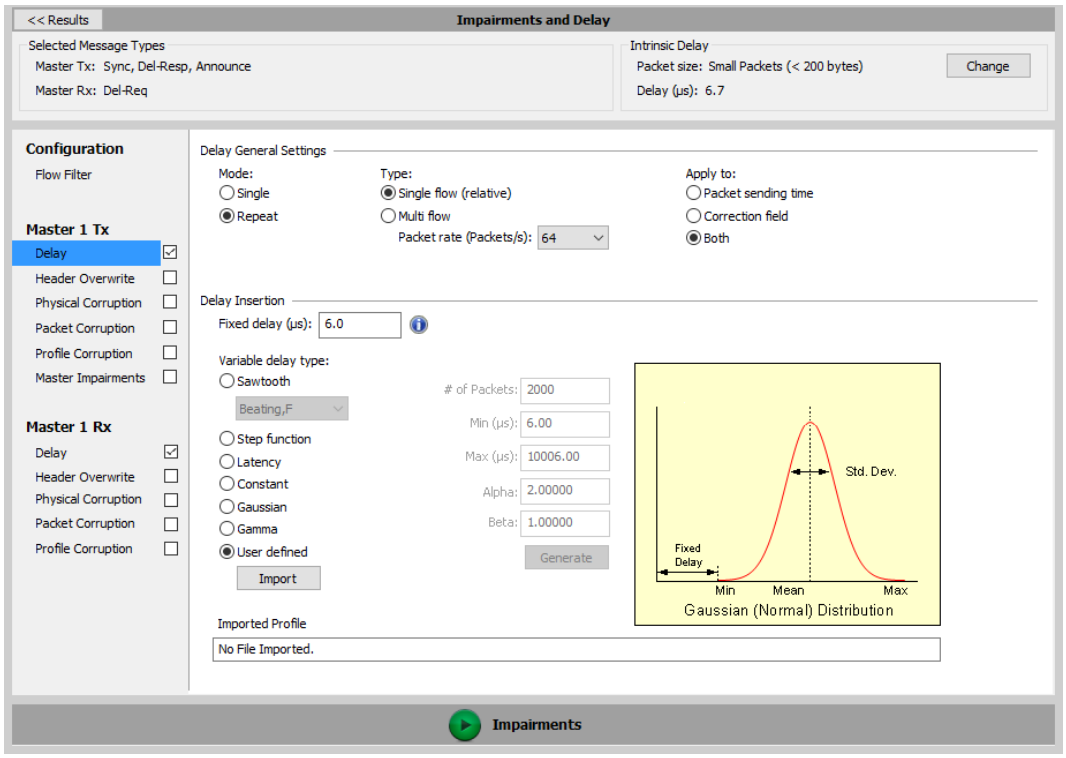



CAT - Calnex Analysis Tool v20.0
Application
System
Help
Select File
Select Metrics
View Results
Generate Report
Export
Calculate
100%
Calnex
TIE / ESMC
MTIE
TDEV
E1
G.8262 Wander Generation EEC Op1
E1
TDEV [ns]
Observation Window [s]
Mask Status
TIE E1
PASS
MTIE E1
PASS
TDEV E1
PASS
Metric Statistics
Min [ns] 0.253
Max [ns] 1.045
Max-Min [ns] 0.792
Chart Tools
Markers Editor
Marker 1
Marker 2
Chart & Zoom mode
Fit
Overlay
Stacked
Visible Elements
Errors
Labels
Markers
Autohide Threshold
Statistics
Save As Image
Resolution
Auto
Masks
E1
G.8262 Wander Generation EEC Op1
Parameters
No Parameters

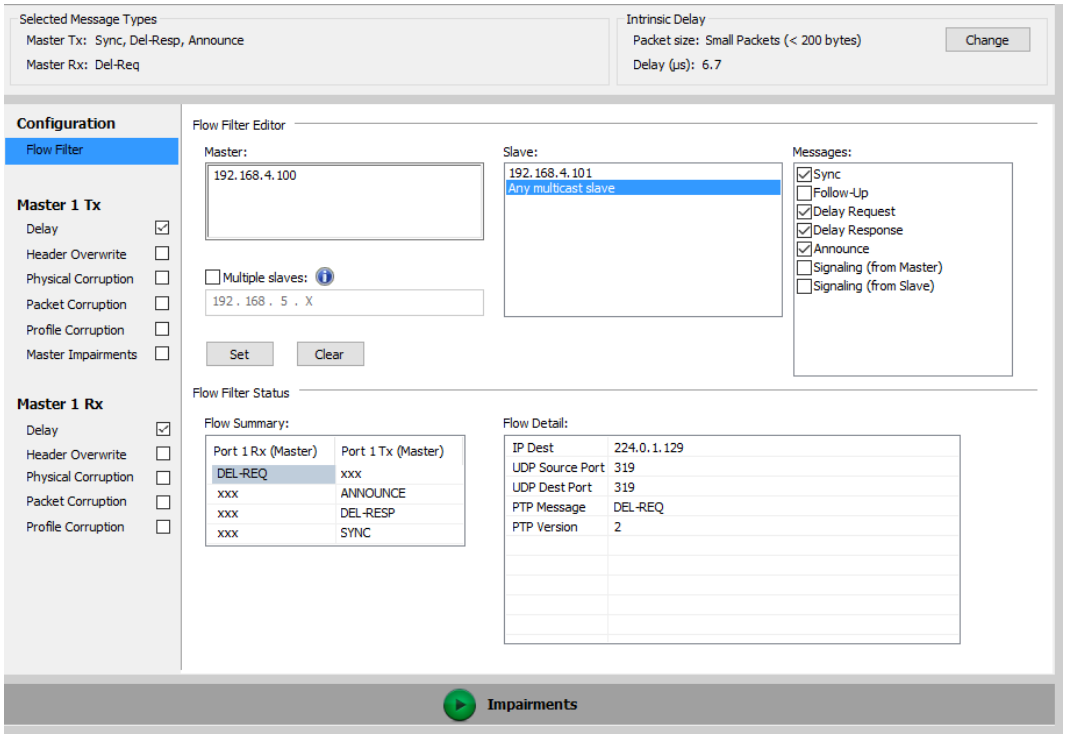
3.8 Adding Impairments and Delays to IEEE1588 messages in Master Clock-Slave Clock Emulation mode

Select 

to display the impairment **Configuration** window. This allows configuration of various types of packet delay and corruptions to be applied to the PTP packets flowing through Paragon-X in both directions. Multiple impairments may be applied simultaneously by ticking the appropriate checkboxes for transmitted (Tx) and received (Rx) packets.

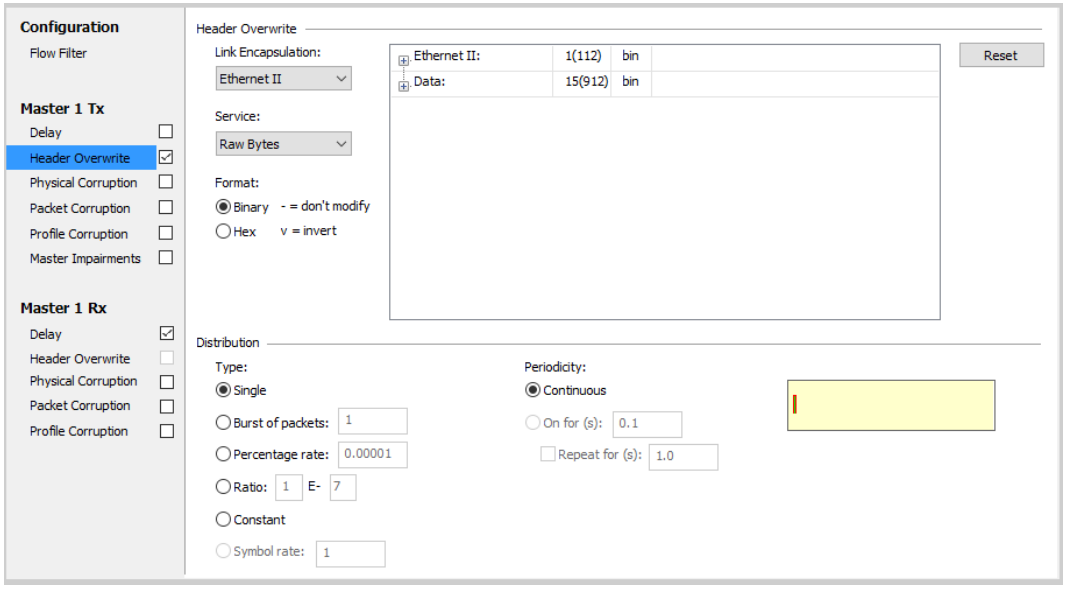


The **Flow Filter** dialog allows configuration of the Master Clock and Slave Clock device addresses and which message types are to be impaired by entering the appropriate details and ticking or unticking checkboxes for each message type.

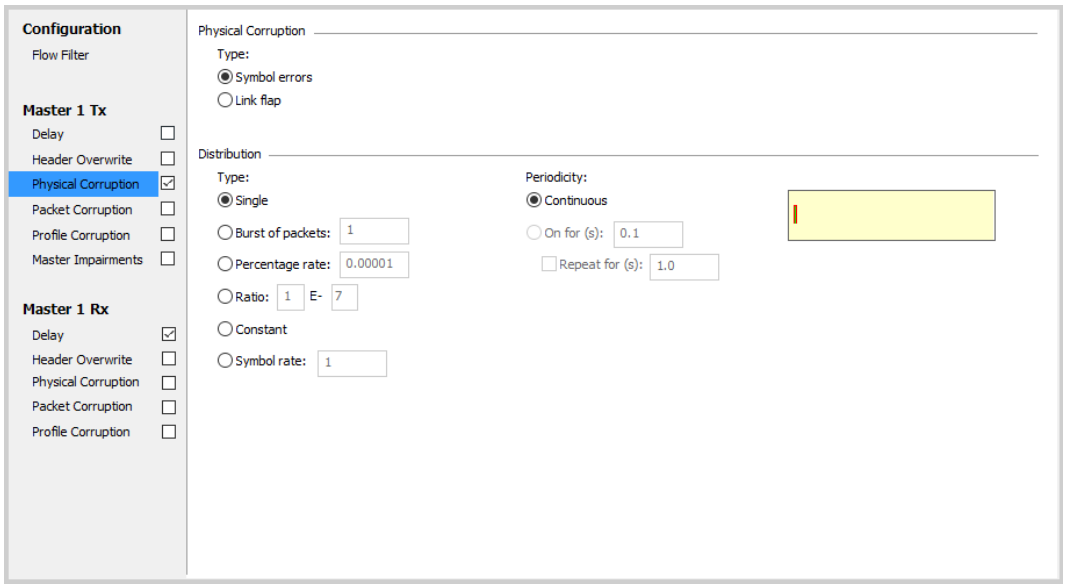


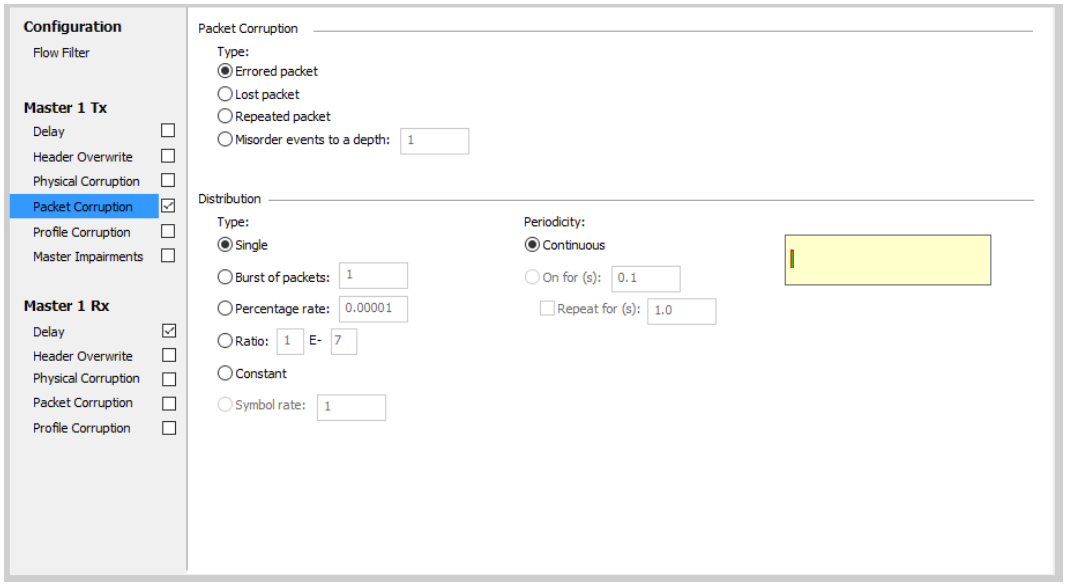
Impairments are added by checking the appropriate boxes in the Master Clock 1 Tx and Master Clock 1 Rx lists, and then configuring options as desired.

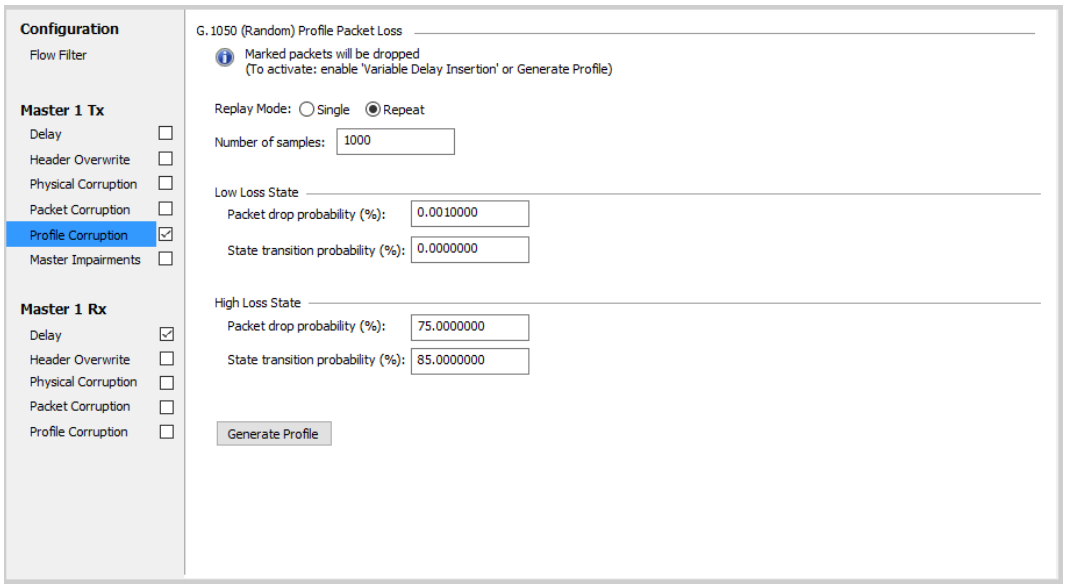
Note: if **Header Overwrite** is enabled, **Physical Corruption** and **Packet Corruption** cannot be selected as all three operate at the physical layer.

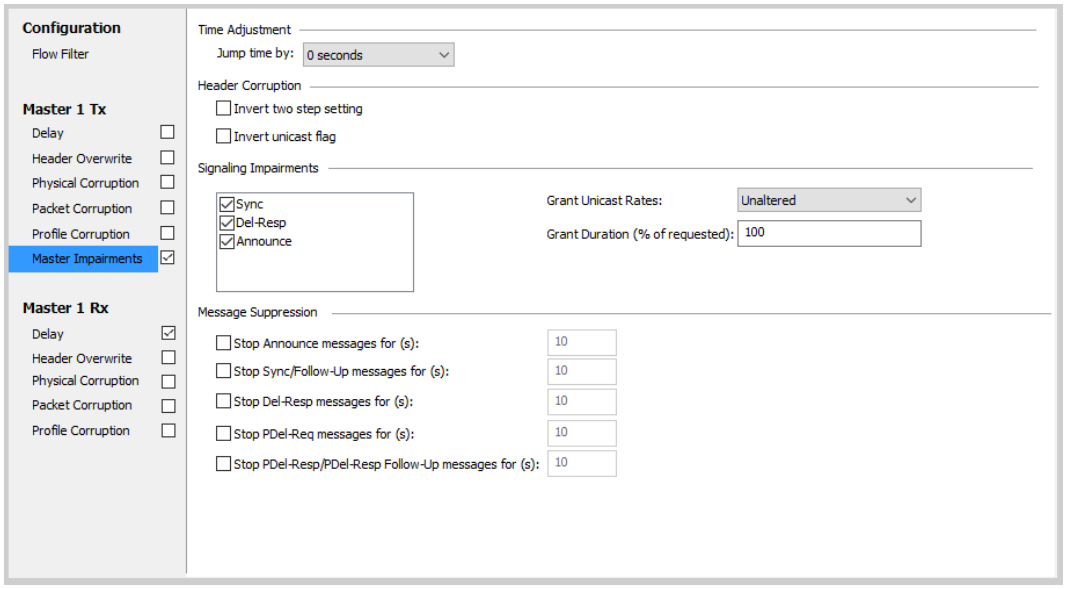


Note: **Physical Corruption** and **Packet Corruption** cannot be simultaneously applied.



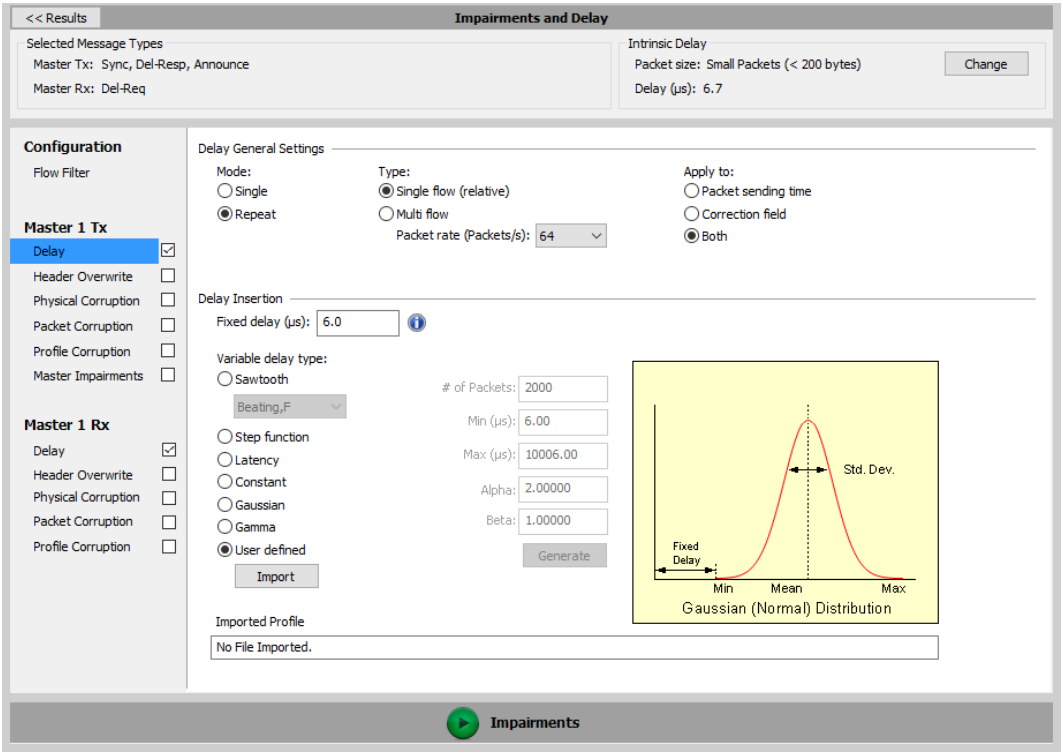

Configuration
Flow Filter
Master 1 Tx
Delay
Header Overwrite
Physical Corruption
Packet Corruption
Profile Corruption
Master Impairments
Master 1 Rx
Delay
Header Overwrite
Physical Corruption
Packet Corruption
Profile Corruption
Packet Corruption
Type:
Errored packet
Lost packet
Repeated packet
Misorder events to a depth: 1
Distribution
Type:
Single
Burst of packets: 1
Percentage rate: 0.00001
Ratio: 1 E- 7
Constant
Symbol rate: 1
Periodicity:
Continuous
On for (s): 0.1
Repeat for (s): 1.0


Configuration
Flow Filter
Master 1 Tx
Delay
Header Overwrite
Physical Corruption
Packet Corruption
Profile Corruption
Master Impairments
Master 1 Rx
Delay
Header Overwrite
Physical Corruption
Packet Corruption
Profile Corruption
G.1050 (Random) Profile Packet Loss
Marked packets will be dropped
(To activate: enable 'Variable Delay Insertion' or Generate Profile)
Replay Mode: Single Repeat
Number of samples: 1000
Low Loss State
Packet drop probability (%): 0.0010000
State transition probability (%): 0.0000000
High Loss State
Packet drop probability (%): 75.0000000
State transition probability (%): 85.0000000
Generate Profile


Configuration
Flow Filter
Master 1 Tx
Delay
Header Overwrite
Physical Corruption
Packet Corruption
Profile Corruption
Master Impairments
Master 1 Rx
Delay
Header Overwrite
Physical Corruption
Packet Corruption
Profile Corruption
Time Adjustment
Jump time by: 0 seconds
Header Corruption
Invert two step setting
Invert unicast flag
Signaling Impairments
Sync
Del-Resp
Announce
Grant Unicast Rates: Unaltered
Grant Duration (% of requested): 100
Message Suppression
Stop Announce messages for (s): 10
Stop Sync/Follow-Up messages for (s): 10
Stop Del-Resp messages for (s): 10
Stop PDel-Req messages for (s): 10
Stop PDel-Resp/PDel-Resp Follow-Up messages for (s): 10

3.9 Applying packet delays

1. Select the Delay row, and ensure the Delay checkbox is ticked:



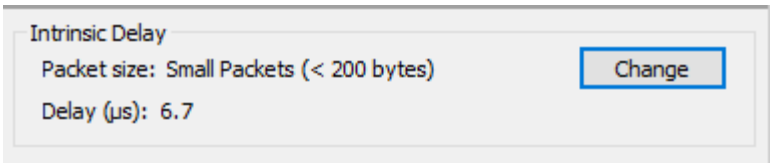
2. Choose whether the delay profile should be repeated or applied only once by selecting the relevant radio button.
3. For most test scenarios, **Single Flow (relative)** is the appropriate type of delay application. This will apply each delay value from the delay profile (see below) in turn to the incoming PTP packet stream i.e. applied delays are additive to the ingress timing delay of the packet. **Multi Flow** is described in Appendix 3 of this document.
4. Select how the delay will be applied:

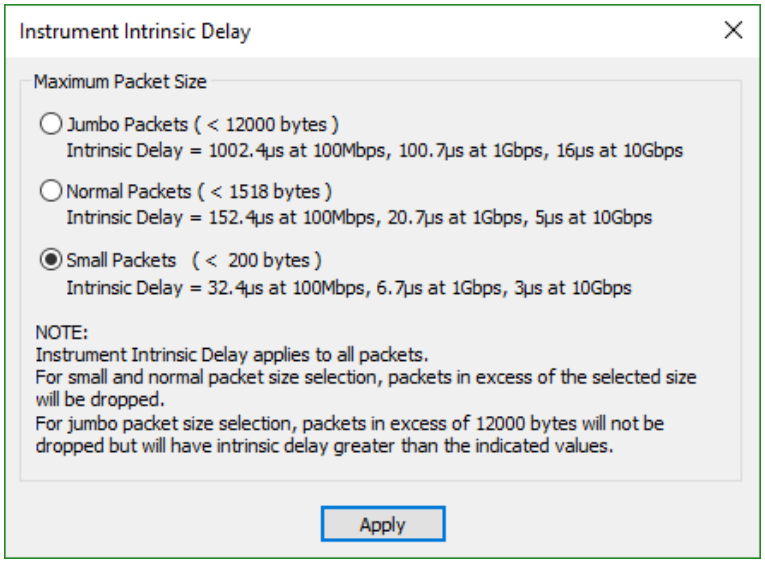
Apply to: ◉ Packet sending time ○ Correction field ○ Both	The packet is delayed by the value read from the delay profile.
	Emulates a TC* by incrementing the message CF* by the delay value.
	Emulates a TC* by applying the delay value to the message CF* and simultaneously delays the packet by the same value.

*TC = transparent clock

*CF = correctionField

5. A Fixed Delay can be applied to all packets flowing through Paragon-X. The minimum value is dependent on the line rate chosen in **Setup Interface** and the packet size selected in the **Intrinsic Delay** - **Change** dialog:

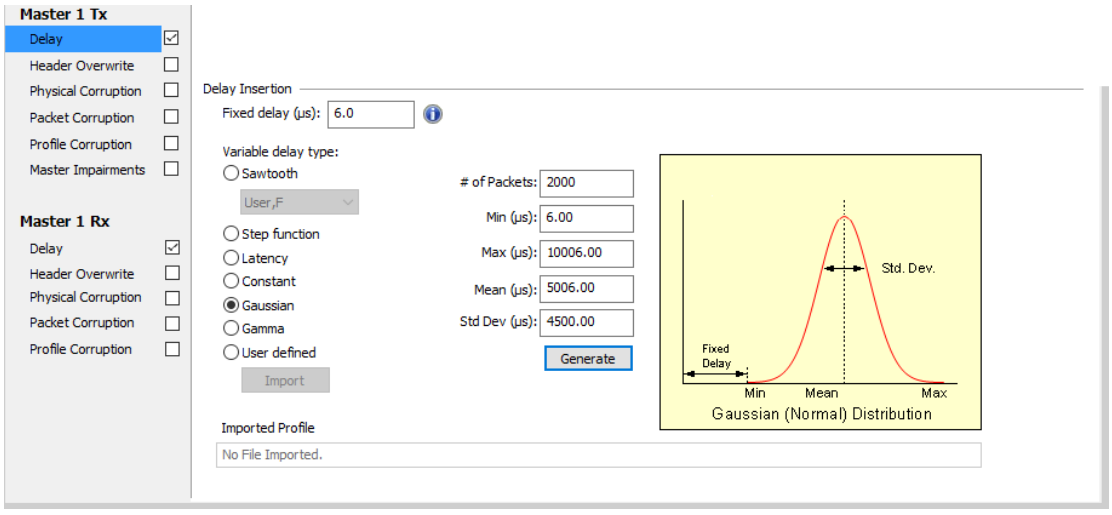




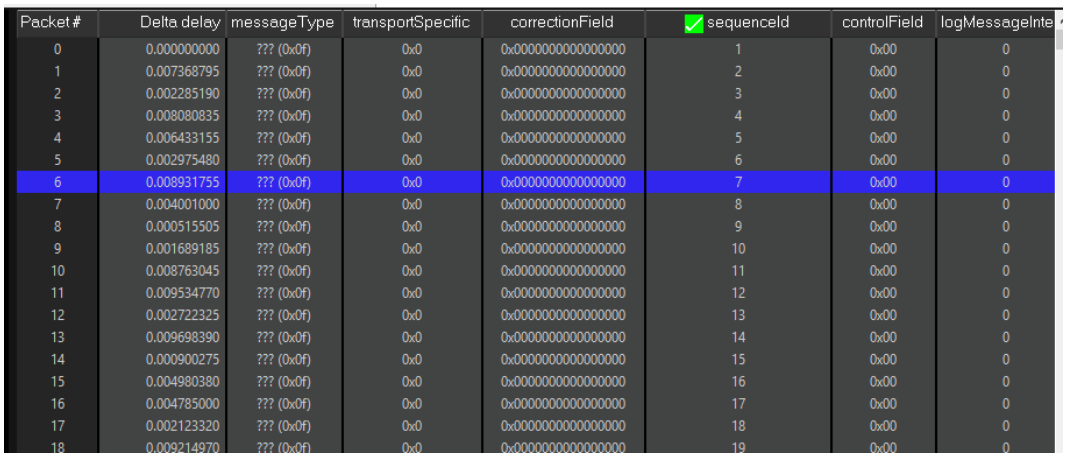
and the maximum 2s plus the intrinsic delay e.g. 2,000,006µs for the above configuration.

6. Different types of variable delay can be applied by clicking the appropriate radio button.
   - **G.8261 Sawtooth profiles (Beating Delay on faster stream or slower stream)**
   - **Step Function**
   - **Latency**
   - **Constant**
   - **Gaussian**
   - **Gamma**
   - **User Defined**

7. Selecting any of these delay profiles (except **User Defined**) will display and allow configuration of their relevant parameters.



8. Once suitable values have been entered, the delay profile can be generated by clicking Generate. This will display the generated packets in the usual capture window format:



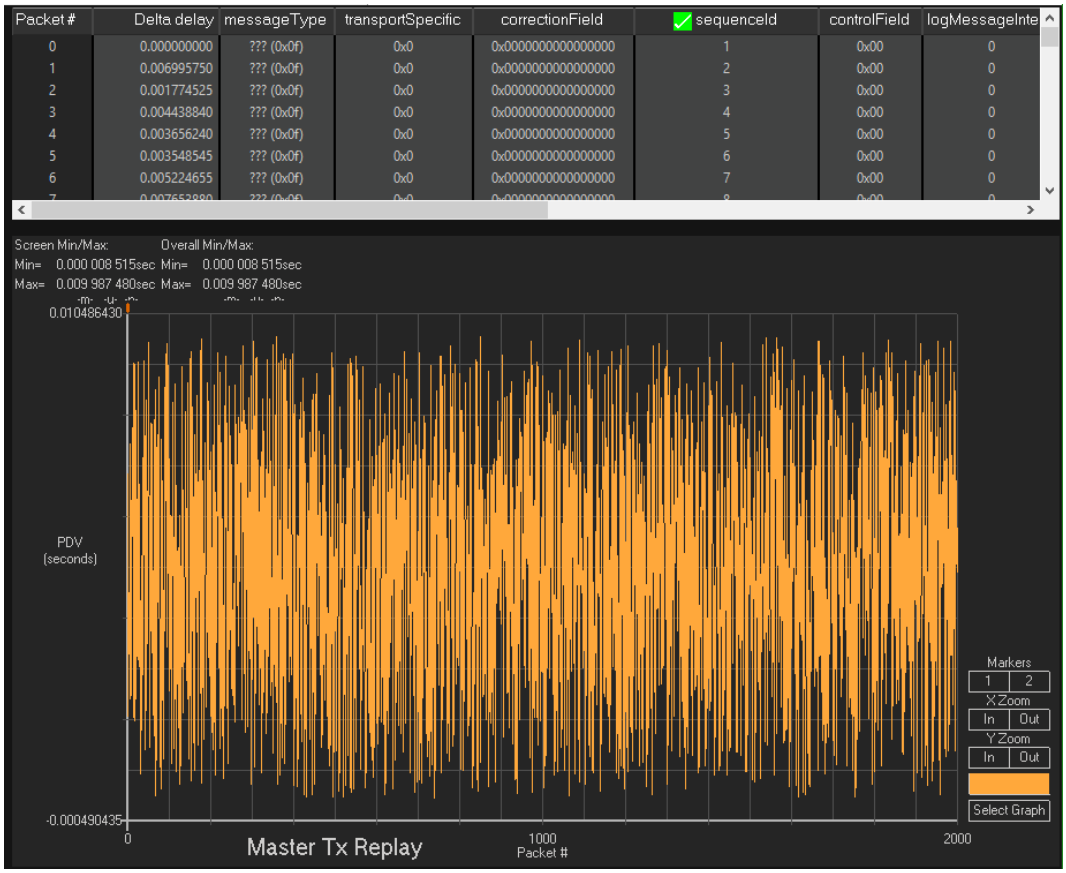
Packet #	Delta delay	messageType	transportSpecific	correctionField	sequenceId	controlField	logMessageInte
0	0.000000000	??? (0x0f)	0x0	0x0000000000000000	1	0x00	0
1	0.007368795	??? (0x0f)	0x0	0x0000000000000000	2	0x00	0
2	0.002285190	??? (0x0f)	0x0	0x0000000000000000	3	0x00	0
3	0.008080835	??? (0x0f)	0x0	0x0000000000000000	4	0x00	0
4	0.006433155	??? (0x0f)	0x0	0x0000000000000000	5	0x00	0
5	0.002975480	??? (0x0f)	0x0	0x0000000000000000	6	0x00	0
6	0.008931755	??? (0x0f)	0x0	0x0000000000000000	7	0x00	0
7	0.004001000	??? (0x0f)	0x0	0x0000000000000000	8	0x00	0
8	0.000515505	??? (0x0f)	0x0	0x0000000000000000	9	0x00	0
9	0.001689185	??? (0x0f)	0x0	0x0000000000000000	10	0x00	0
10	0.008763045	??? (0x0f)	0x0	0x0000000000000000	11	0x00	0
11	0.009534770	??? (0x0f)	0x0	0x0000000000000000	12	0x00	0
12	0.002722325	??? (0x0f)	0x0	0x0000000000000000	13	0x00	0
13	0.009698390	??? (0x0f)	0x0	0x0000000000000000	14	0x00	0
14	0.000900275	??? (0x0f)	0x0	0x0000000000000000	15	0x00	0
15	0.004980380	??? (0x0f)	0x0	0x0000000000000000	16	0x00	0
16	0.004785000	??? (0x0f)	0x0	0x0000000000000000	17	0x00	0
17	0.002123320	??? (0x0f)	0x0	0x0000000000000000	18	0x00	0
18	0.009214970	??? (0x0f)	0x0	0x0000000000000000	19	0x00	0

To return to the impairments screen, click on the Add Impairments/ Delay button.

Note: the displayed correctionField values will always show as 0x00 in this view as the **Delta delay** value is used for both packet delay and correctionField incrementing.

9. The **User Defined** option can be used to import for replay a **.cpd, .cpw, .clxz** or **.csv** file previously saved on a Paragon-X. Clicking Import will open a window to allow the import of these or a user-created **.csv** file. A status bar will show the progress of the import.

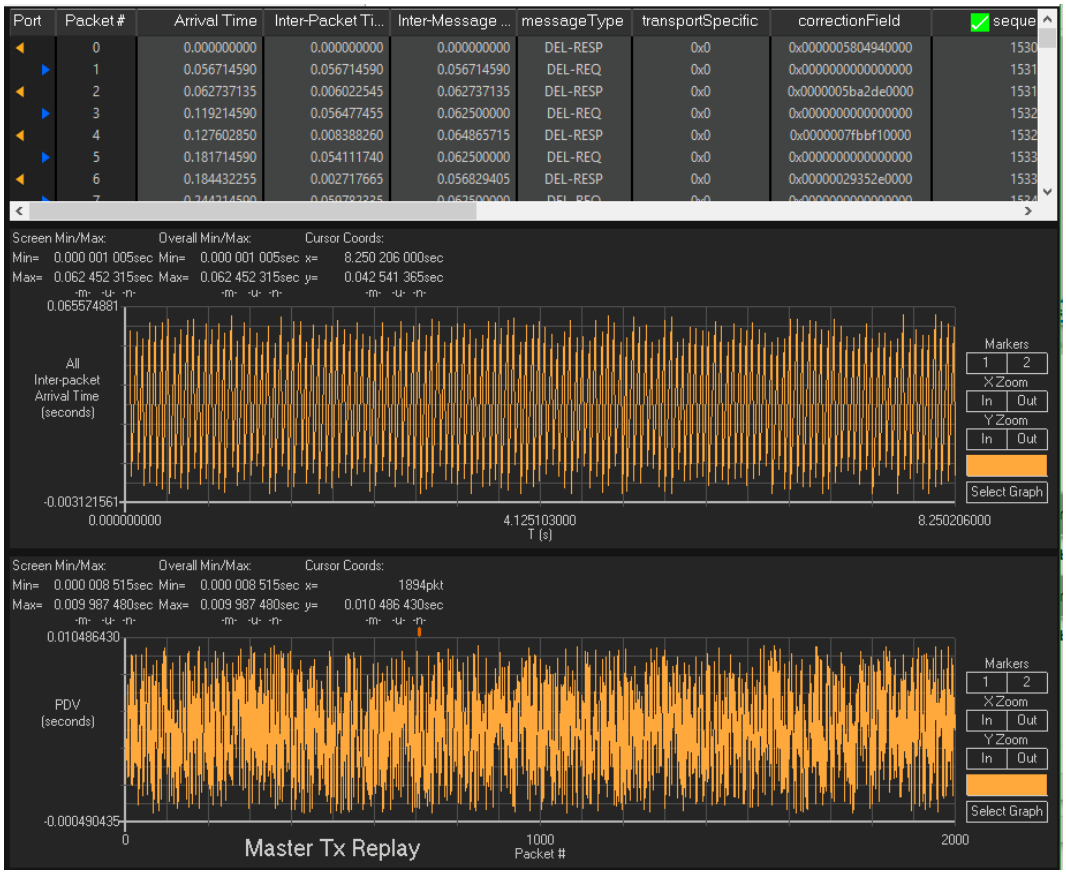
10. To start applying the impairment profile, click Impairments or in the icon bar. Click << Results to show the calculated delay profile.



The graph has a small red vertical bar above it which shows the progress of the delay profile replay.

Note: when in Master Clock-Slave Clock Emulation (MSE) mode, the replay will not start unless MSE is also started.

When a capture is started the captured data will displayed above the delay profile, with the progress indicator showing progression through the profile:



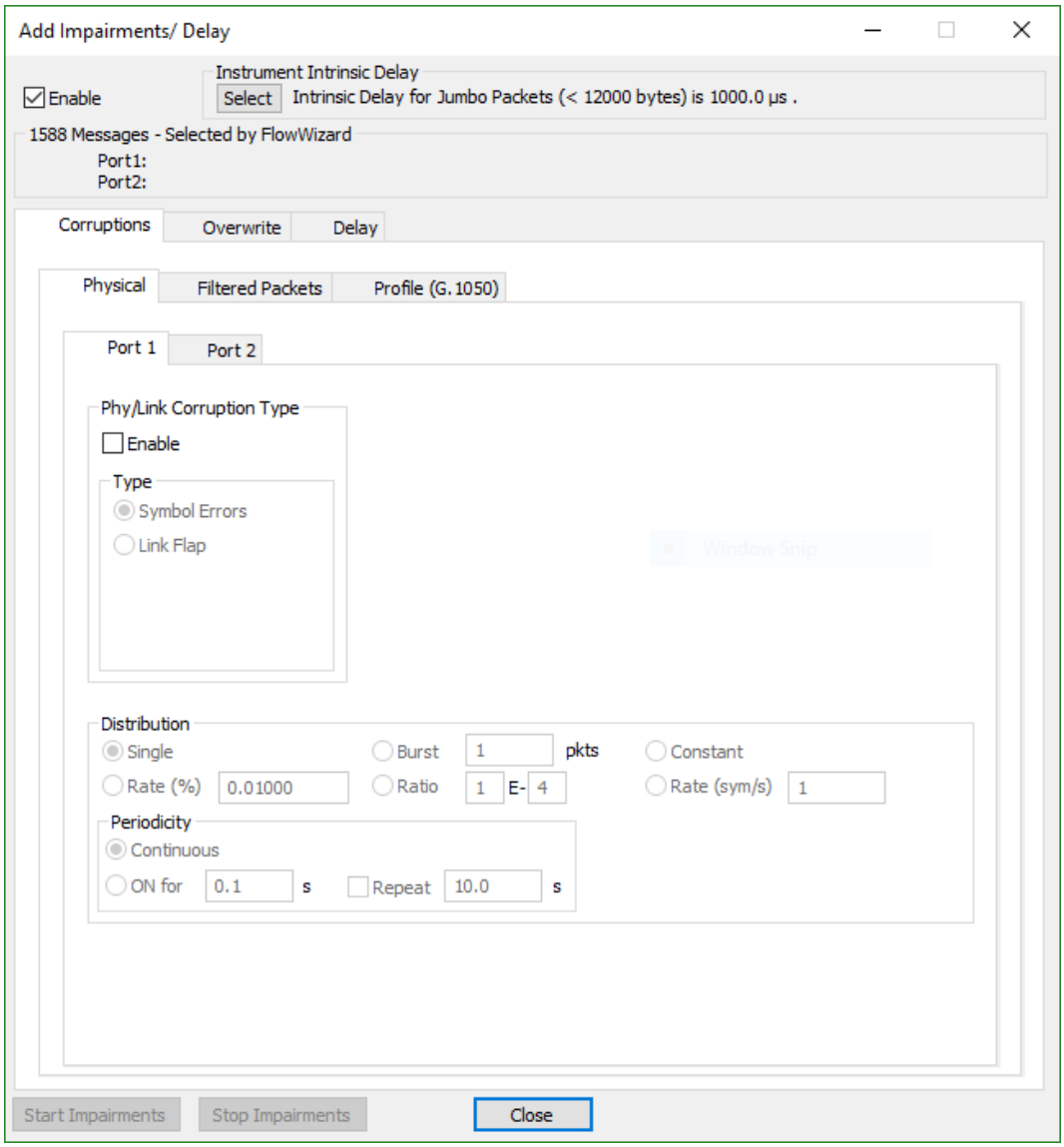
Replay can be stopped by clicking 

or 

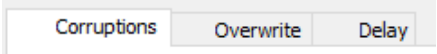
3.10 Adding Impairments and Delays to IEEE1588 messages in non-Master Clock-Slave Clock mode

Select 

to display the impairment configuration window. This allows configuration of various types of packet delay and corruptions to be applied to the PTP packets flowing in both directions through Paragon-X. It is possible to add lost/errored packets simultaneous to a delay being applied to the packets.

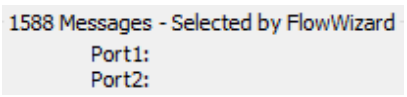


Corruption, Overwrite or **Delay** is applied by configuring settings after selecting the appropriate tab:

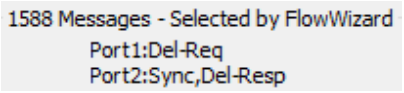


Note: Impairments are applied to message types which have been selected using **Flow Wizard**. If no streams have been selected, no impairments will be applied.

No streams selected:

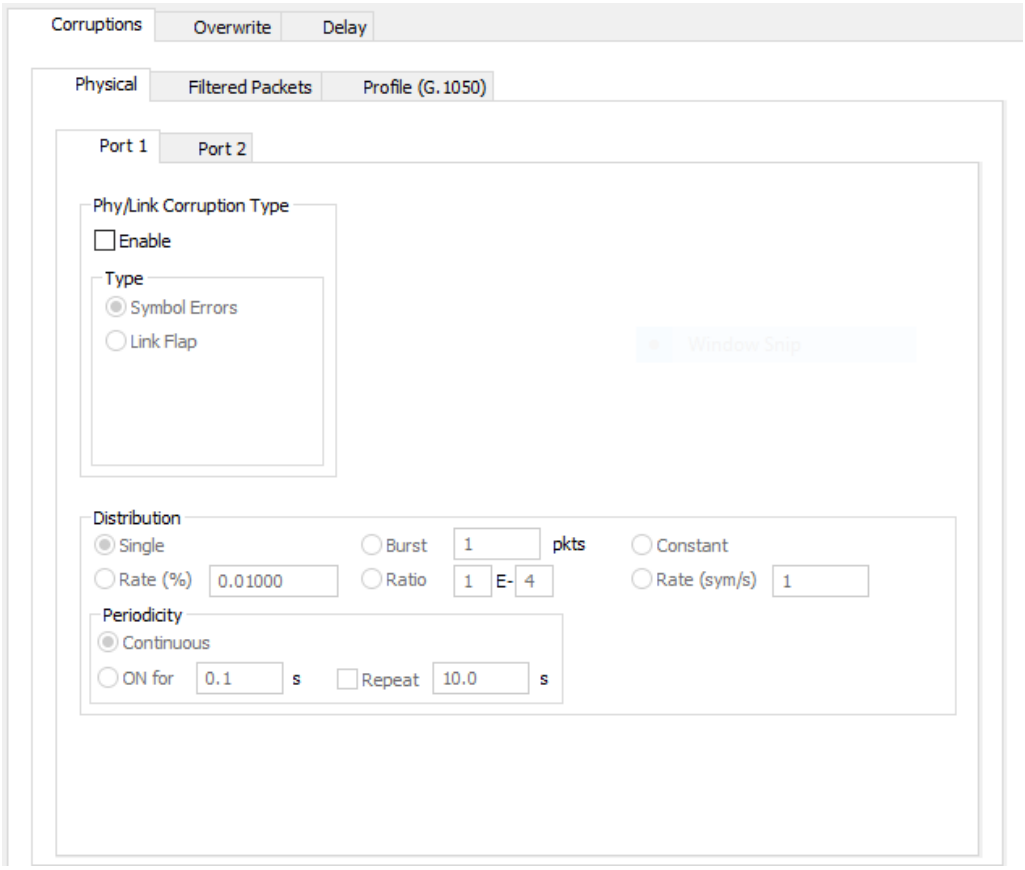


Streams selected:

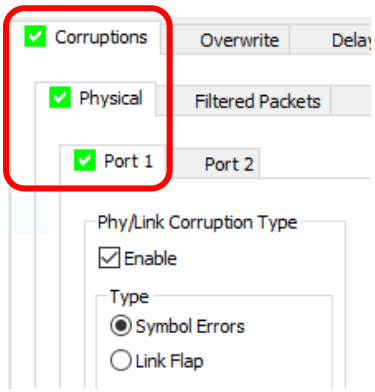


Adding corruptions

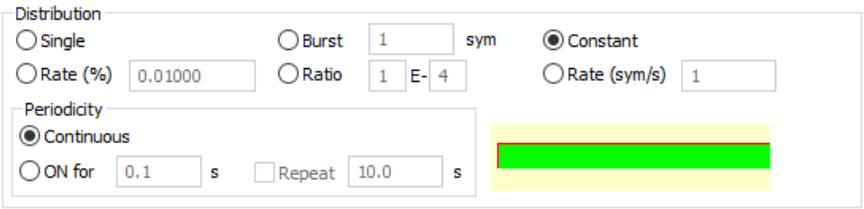
1. Use the **Corruptions** tab to configure the applied settings:



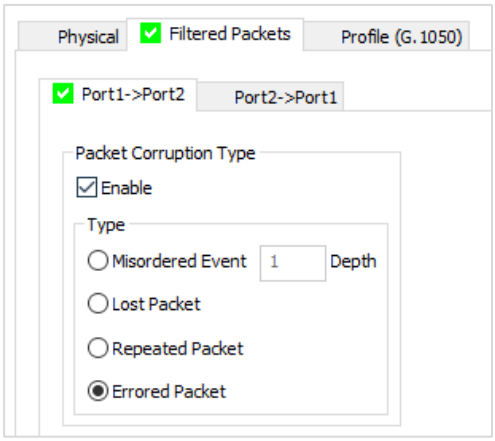
2. Select the port to which corruptions will be applied. Only one port can be enabled at any given time so ensure the **Enable** checkbox is ticked for the desired port. Green ticks will be shown on the various levels to indicate corruptions have been enabled:



3. The type of corruption is selected by clicking the relevant radio button, and then how the corruption is to be applied can be configured:



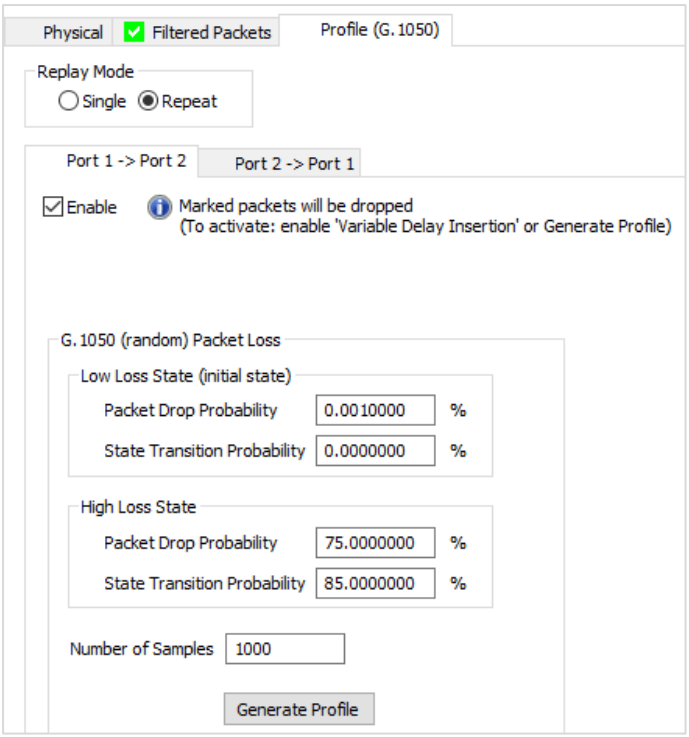
Using the **Filtered Packets** tab similarly allows the configuration of packet error types in either direction, and how they are applied:



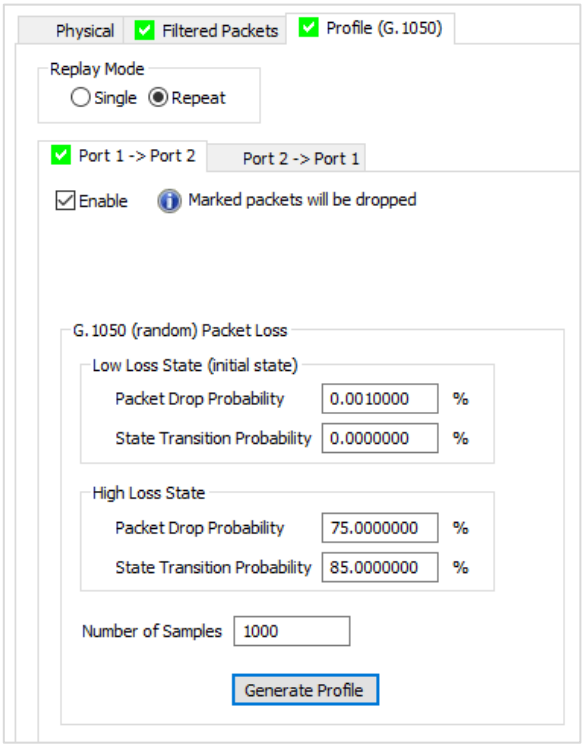
The **Profile (G.1050)** tab allows packet loss as per G.1050. Low and high rate packet losses may be configured in both port 1 to port 2 and port 2 to port 1 directions simultaneously with each other and with either **Filtered Packets** or **Physical Corruptions**.

Packet loss configured in this option will only be applied if the necessary delay profile is generated by clicking the Generate Profile button and the **Enable** checkbox is ticked:

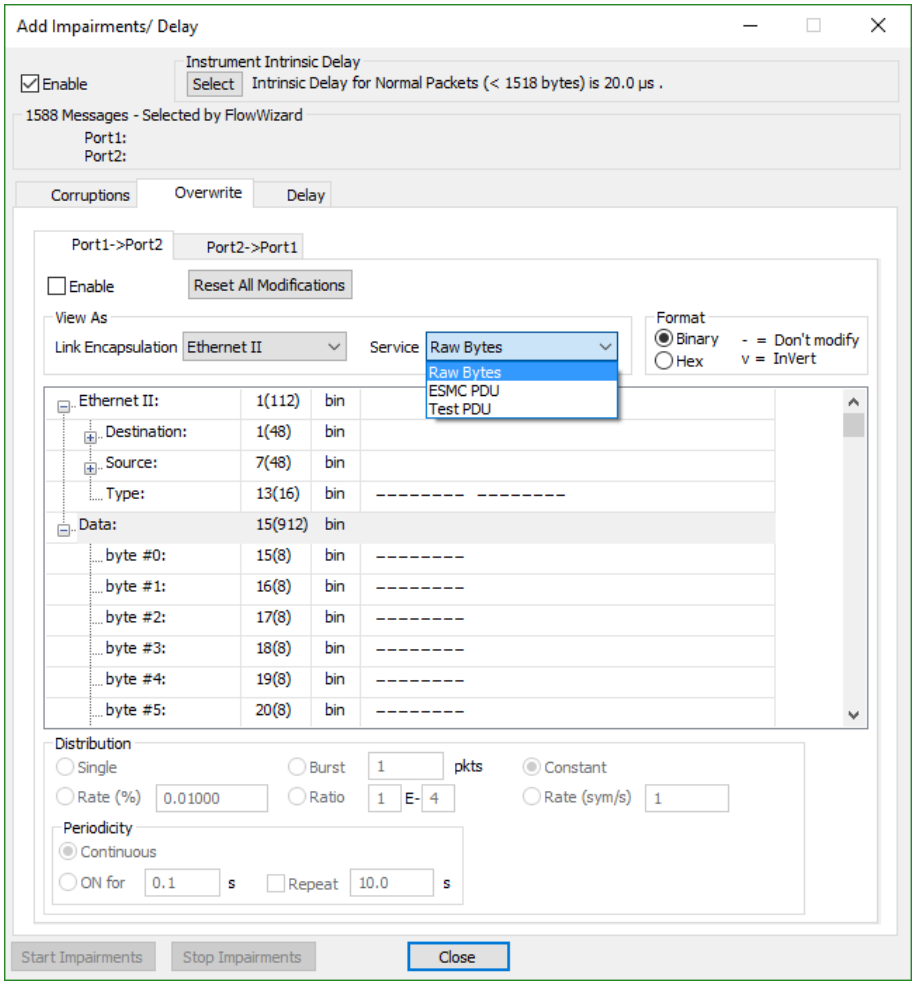
- **Enable** checkbox ticked, but no profile generated, so no impairment will be applied:

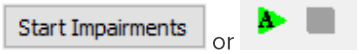


- Profile generated and **Enable** checkbox ticked; ☑ indicates impairment will be applied:

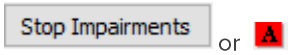


4. Overwrites can be configured and enabled in the **Overwrite** tab. Only one direction (Port 1 → Port 2 or Port 2 → Port 1) can be enabled at a time: if one is chosen the other direction will not be available unless the first is disabled. Ethernet II, 802.1Q and 802.1QinQ encapsulations are available, with full control over what bits are overwritten and with what data.



5. To start applying impairments, click 

or

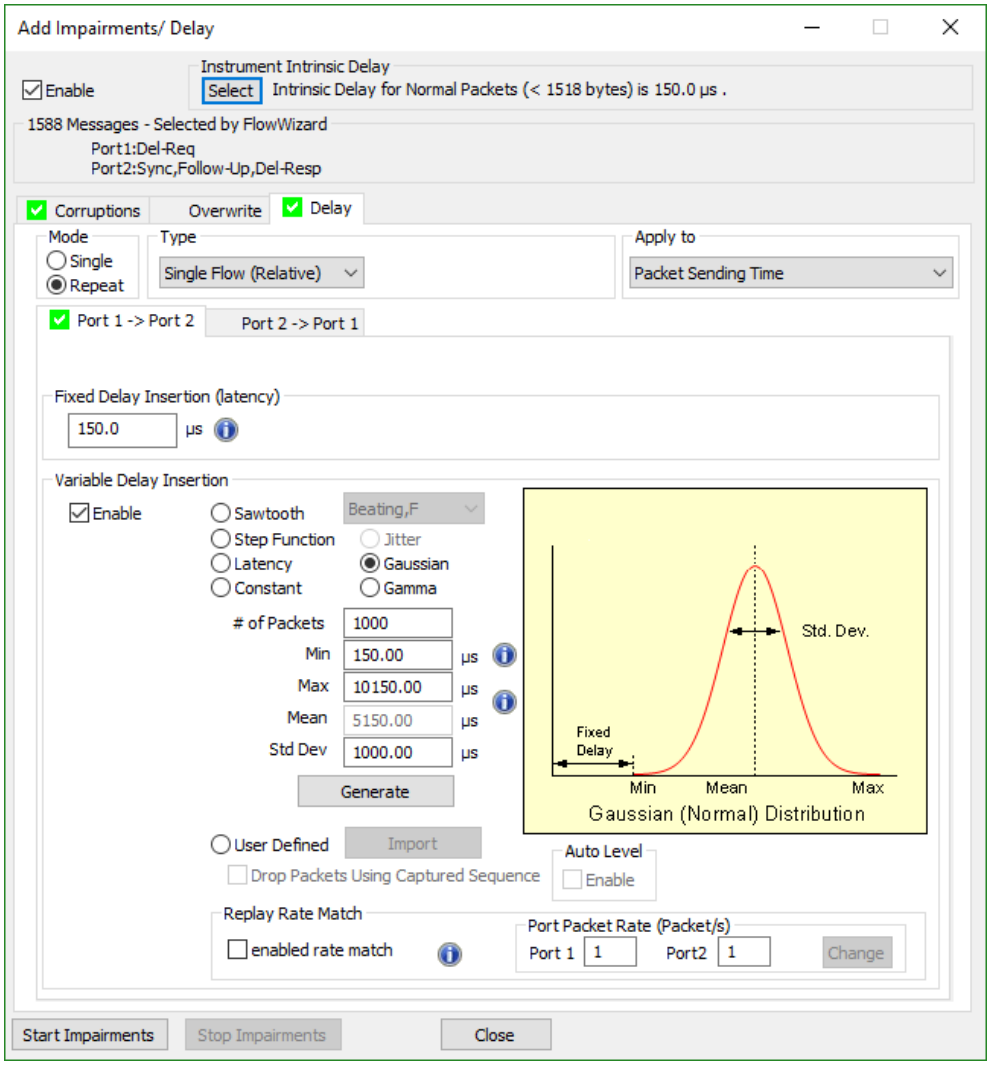
6. To stop the impairments click 

or

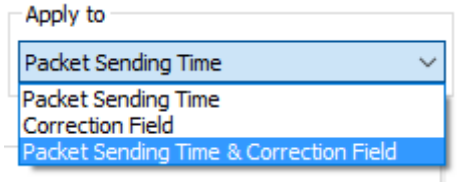
Adding bi-directional delays

1. Click the **Delay** tab 

2. Ensure that the appropriate message types have been selected in the **Flow Filter**, that the relevant **Intrinsic Delay** is set, and that impairments have been enabled, then tick the **Enable** checkbox under the **Variable Delay insertion (latency)** section to allow configuration of the delays:



3. Configure whether the delay profile will be applied repeatedly or run once by clicking the appropriate **Mode** radio button.
4. Use the **Type** dropdown menu to select whether the delay will be applied to a single or multiple flows (see Appendix 3 for Multiple Flow details).
5. Select how you want the delay to be applied – default is to the Packet Sending Time.



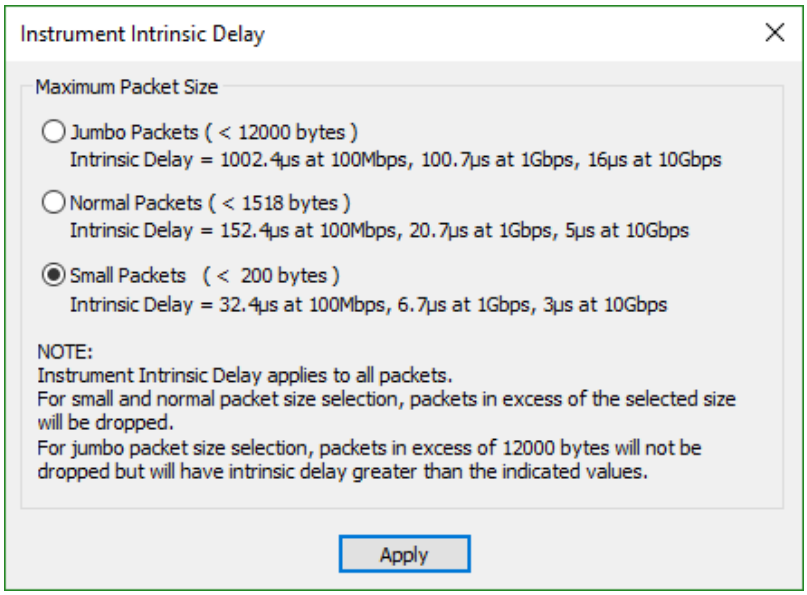
Applied to	Description
Packet Sending Time	The packet is delayed by the value read from the delay profile.
Correction Field	Emulates a TC* by incrementing the message CF* by the delay value.
Packet Sending Time & Correction Field	Emulates a TC* by applying the delay value to the message CF* and simultaneously delays the packet by the same value.

*TC – transparent clock

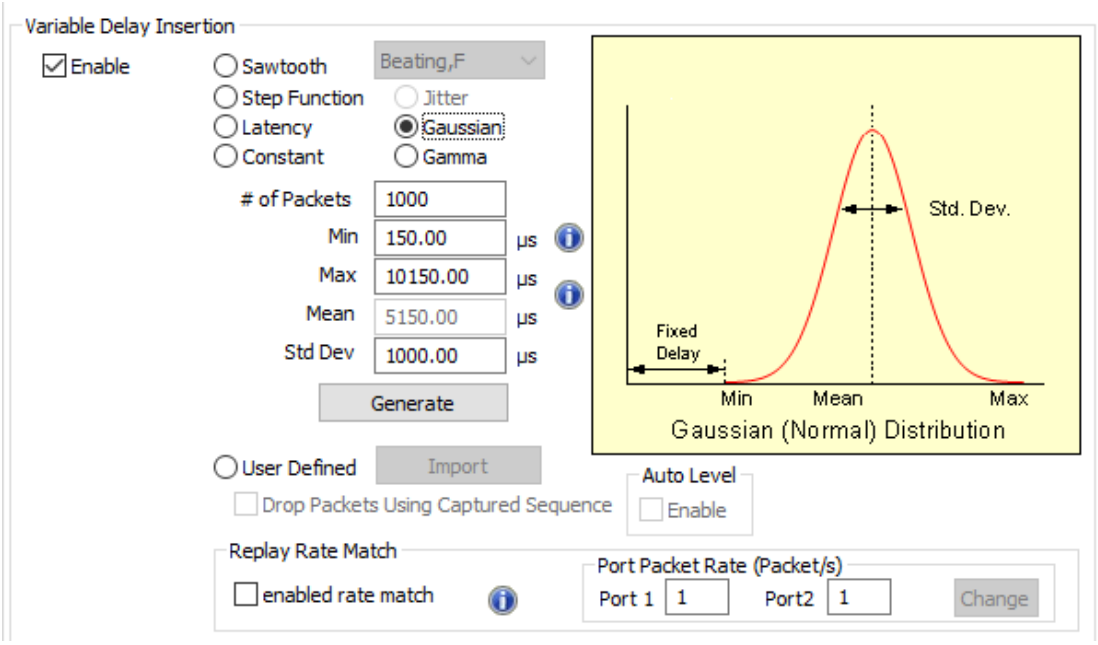
*CF – correction Field

6. Delay profiles can be enabled and configured independently for flows Port 1 → Port 2 and Port2 → Port 1 to allow testing of Asymmetry in the network. Each may be configured by selecting the appropriate tab. In the screenshot below, both directions have been enabled, as indicated by the green ticks.

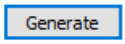
7. All impaired packets flowing through Paragon-X experience a fixed delay. The minimum is dependent on the chosen line rate, and the configurable maximum is 2s plus this intrinsic delay.



8. Different types of delay profile may be selected by clicking the appropriate radio button ○



- **G.8261 Sawtooth profiles** (Beating Delay on faster stream or slower stream)
- **Step Function**
- **Latency**
- **Constant**
- **Gaussian**
- **Gamma**
- **User Defined**

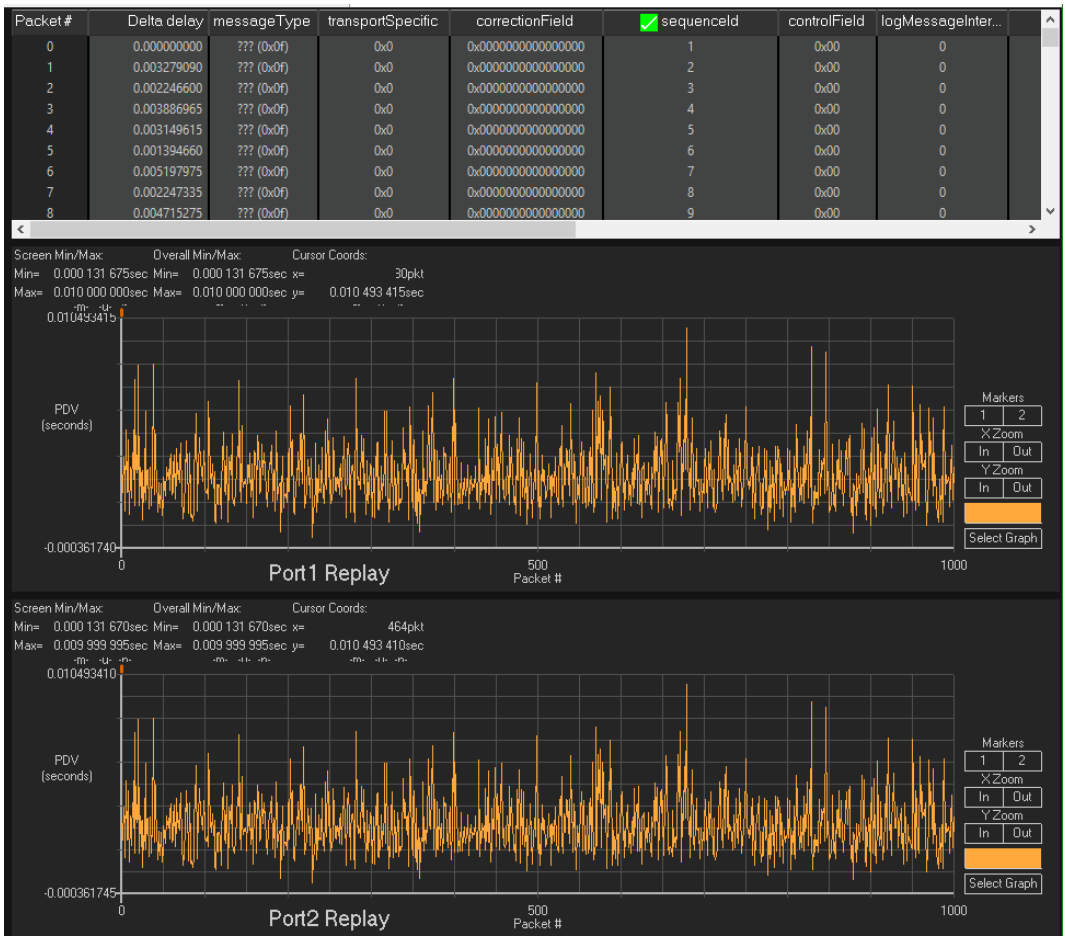
9. Selecting any of these delay profiles (except **User Defined**) will display and allow configuration of their relevant parameters.
10. Once suitable values have been entered, the delay profile should be generated by clicking 

. This will display the generated packets in the usual capture window format in the background.
11. For adding the same or different delays in the other direction. Select the other direction tab and follow steps 1 to 6 above. When delays are being added in both directions there will be a green tick shown in each direction tab as shown below.

12. To start applying impairments, click 

or 

13. The replayed profile for each direction is displayed. The relevant information for each profile is shown above its graph. A small orange progress bar above each graph will show progress through the profile as it is applied.



14. To stop the impairments click Stop Impairments or 

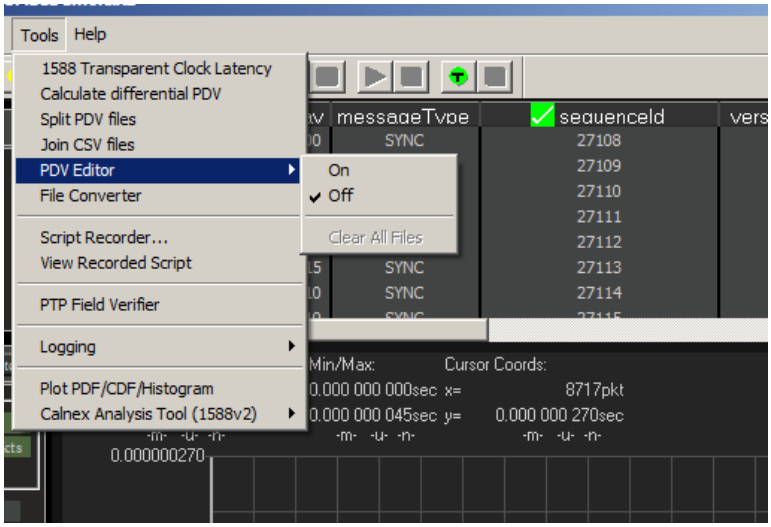
Appendix 1 – Using the PDV Editor

This feature allows captured timing profiles to be manipulated in a number of ways. It is intended to aid experimentation to establish limits of operation and margin testing, and to allow network events to be combined to produce a composite profile which will speed up testing.

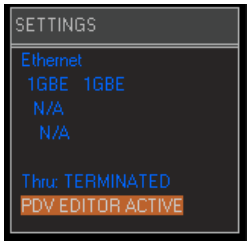
The tool will operate on all profiles captured by Paragon when in IEEE 1588 or Services modes of operation.

1. From the **Tools** dropdown, select ***PDV Editor*** > ***On***.

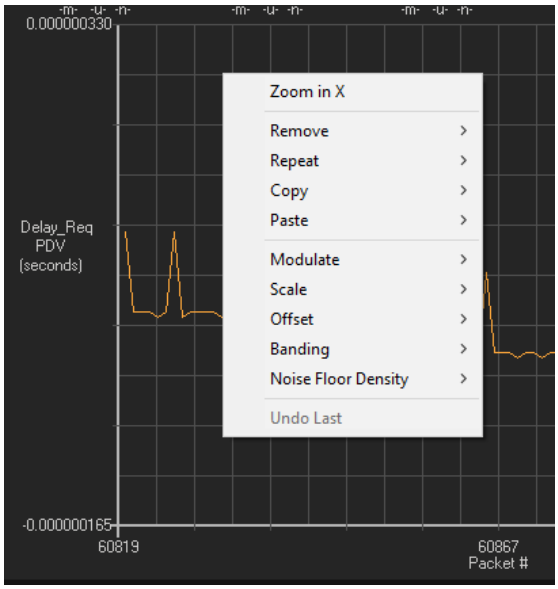
   Note: PDV Editor can only be enabled when a suitable capture file is loaded in the Paragon-X GUI. This may be a recent capture, or a previous one which has been loaded from a .cpd or .clxz file.



   When the profile editing mode is enabled, the **SETTINGS** status section on the GUI will show:



2. Edit the profile by placing the cursor on the graph display and pressing the left mouse button. This will display the menu shown below.

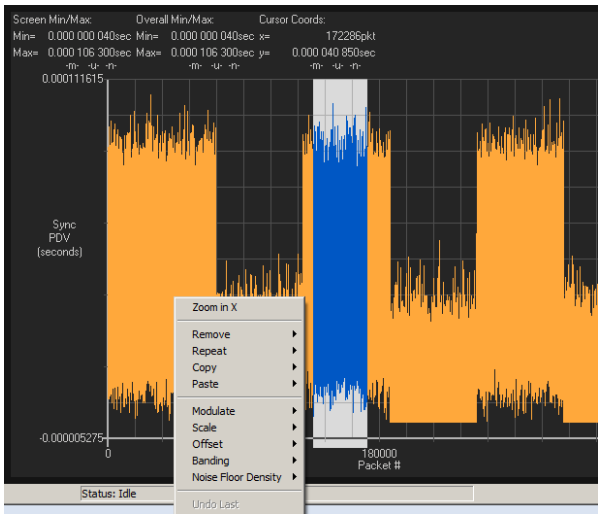


3. The editing functions that can be carried out from this menu are:

a. Remove – allows part of the timing profile to be cut out and disposed of or to retain part of the profile and dispose of the rest. One use of this feature is to extract a short part of the profile to allow it to be replayed to determine if it is a stressful section of a replay which causes a Slave Clock failure.

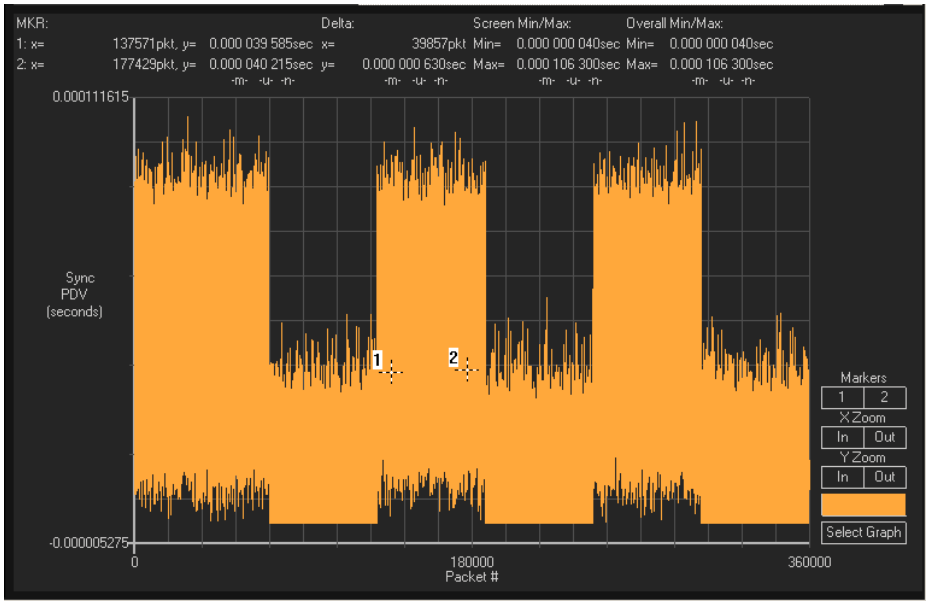
There are two methods of delimiting the section of interest.

The first is to use the mouse. Place the cursor at the start of the section of interest then left button down and drag the mouse to the end of the section of interest. This will highlight the area.

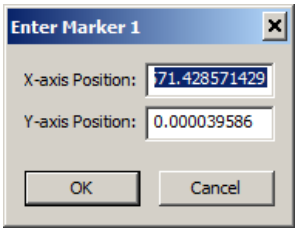


The second way is to use markers. These are set using the **Markers** buttons shown on the screen below.

There are two methods of placing the markers; using the mouse and using the location. In each case both markers should be set. These are marked on the graph as 1 and 2 as shown below.



To use the mouse, click the **Markers** button **1** or **2** and a menu will appear. Select ***Set Marker*** using the mouse then place the cursor at the desired position and left click. The marker will appear as shown in the previous screen shot.



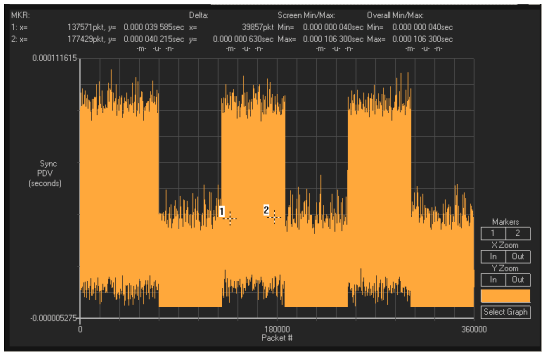
To use the location, click the **Markers** button ***1*** or ***2*** and a menu will appear. Select ***Enter Marker*** manually. A pop-up window will appear as shown opposite. The parameters can then be entered.

Once the area of interest is selected the left mouse should be clicked and then ***Remove*** either the ***Marked*** or ***Non-Marked*** area.

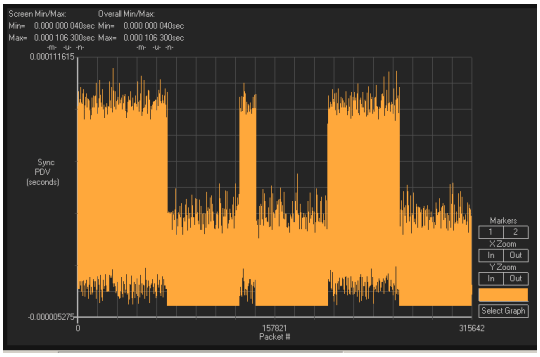
If **Marked** is selected then only the area highlighted is removed and the rest of the profile retained.

If **Non-Marked** is selected then only the highlighted section is retained with the rest being removed of and the rest is kept.

Example of highlighted area deleted from original



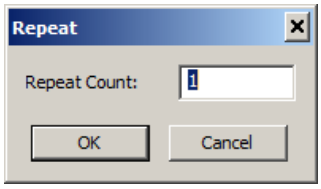
Original Profile



Edited Profile – with section removed

b. **Repeat** – allows a section of a profile to be be repeated a controlled number of times. The whole profile may be repeated or a section repeated within the overall profile.

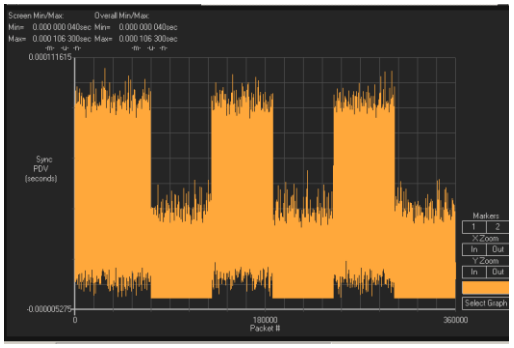
There are 3 sub-selections:



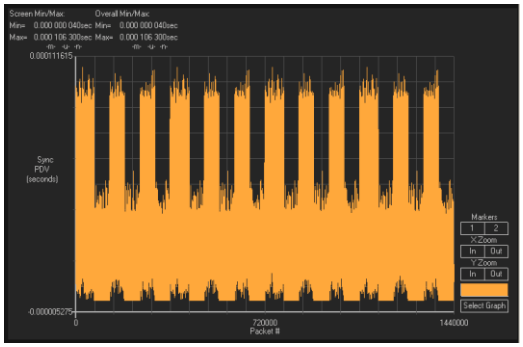
All where the overall profile is repeated the selected number of times. When the All selection is made the pop-up screen opposite is displayed to allow the repeat number to be set.

The range of the repeat number is 1 to 9.

As an example, the following profile will have three additional repeats inserted as shown in the second screen shot.



Original Profile



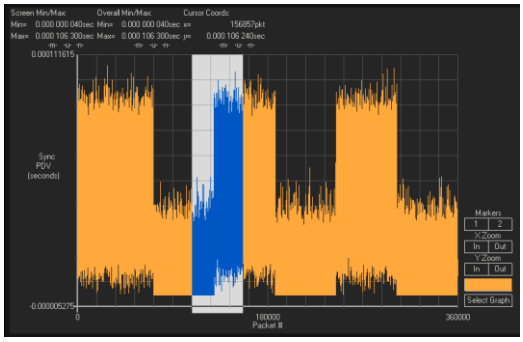
Edited Profile – with repeat count of three

The other two sub-selections allow parts of the profile to be repeated within the overall capture.

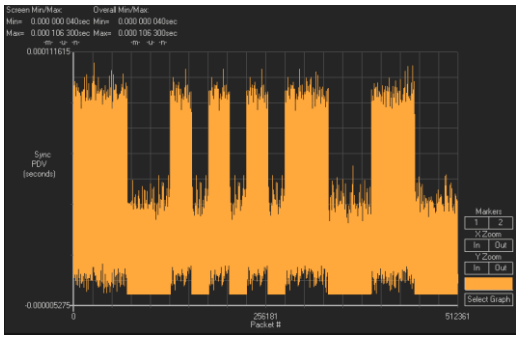
The selections allow the marking of the sections to be performed either using the mouse or using markers as introduced in the **Remove** section.

The following illustrates the repeating of partial profile three times.

Original profile with section highlighted using the mouse click and drag.



Original Profile



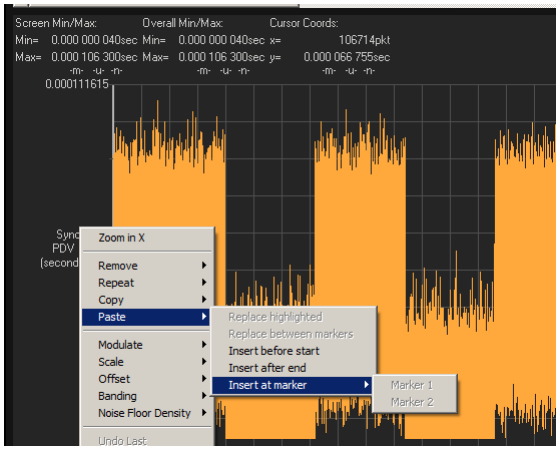
After repeating three times

c. **Copy and Paste** – allow parts of the profile to be copied then inserted into a later part of the profile.

The modes for Copy are:

- **All** where the whole profile is copied
- **Highlighted** where the section identified by using the mouse click and drag is copied
- **Marked** where the two markers identify the section to be copied

The modes for Paste are shown below.



- **Replace highlighted** allows the data in the copy buffer to replace the highlighted area.
- **Replace between markers** allows the data in the copy buffer to replace the data between the two markers. Operation of the markers is explained in the **Remove** section.
- **Insert before start** inserts the data in the copy buffer before the start of the data.
- **Insert after end** inserts the data in the copy buffer after the end of the currently loaded data.
- **Insert at marker** inserts the data in the copy buffer at the point marked by the appropriate marker. Operation of the markers is explained in the **Remove** section.

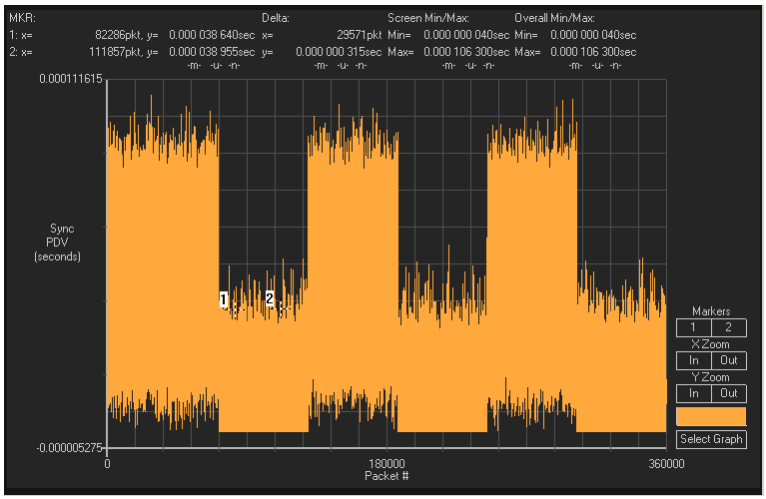
d. **Modulate** – allows sections of the data (graph) to be edited by adding a:

- Step in amplitude
- Sawtooth increase in the values
- Triangle increase in the values

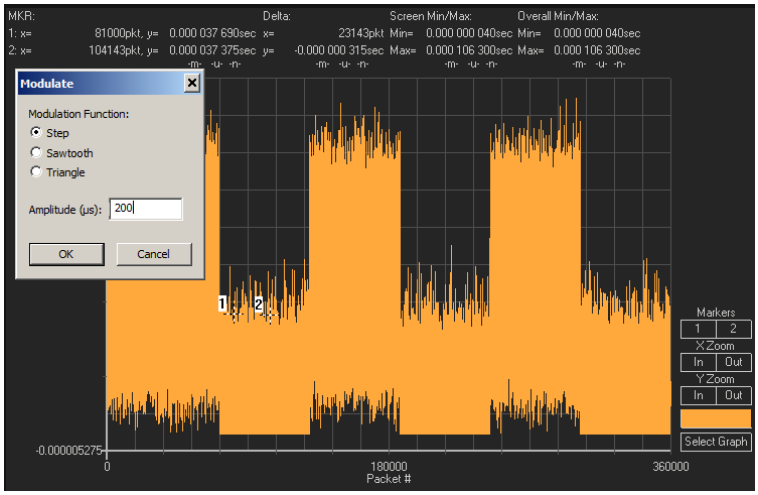
The range over which this change is applied is selectable as **All**, **Highlighted** or **Marked**. These are set as described in the **Remove** section.

As an illustration, the following shows how to apply a step offset to part of a profile.

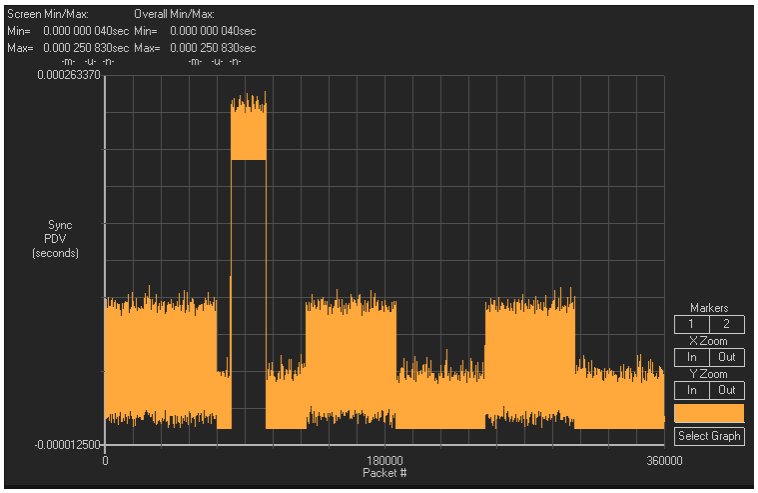
Original profile with section selected using markers.



Add step of 200 microseconds to this section.

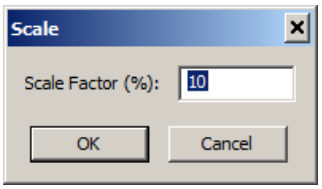


The resultant profile with the 200 microsecond step.



The range of the Modulation Amplitude is 0.1 microseconds to 1 second.

e. **Scale** – allows you to increase or decrease the PDV.

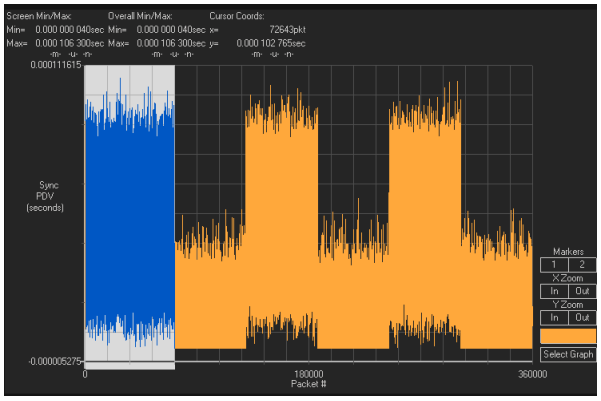


Again, the packets to be impacted are selected from **All**, **Highlighted** or **Marker**. The level of the scaling is set on the pop-up screen shown opposite.

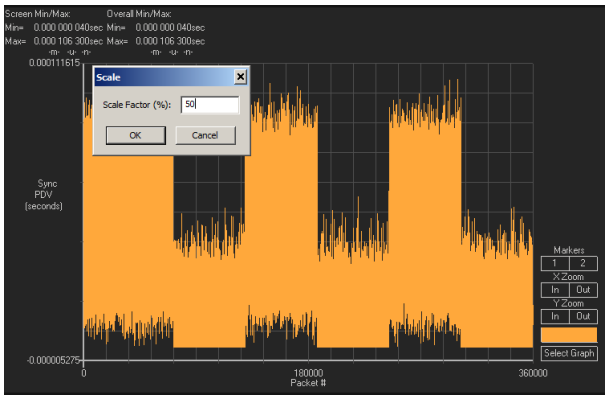
The range of the scaling is 10 – 1000%

As an example, the following will have the first part of the profile scaled to 50% of its original value.

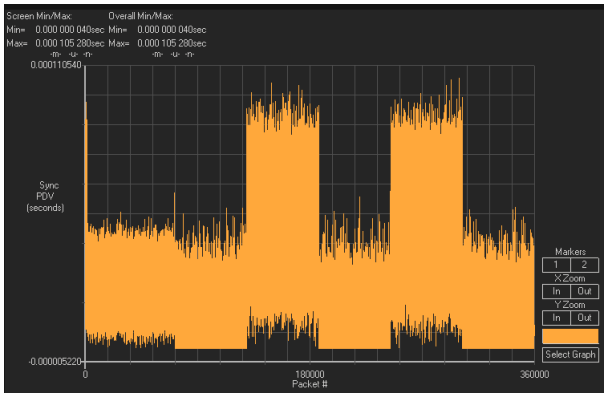
Initial profile with the highlighted section.



With the scale factor set.



The final result is shown below.

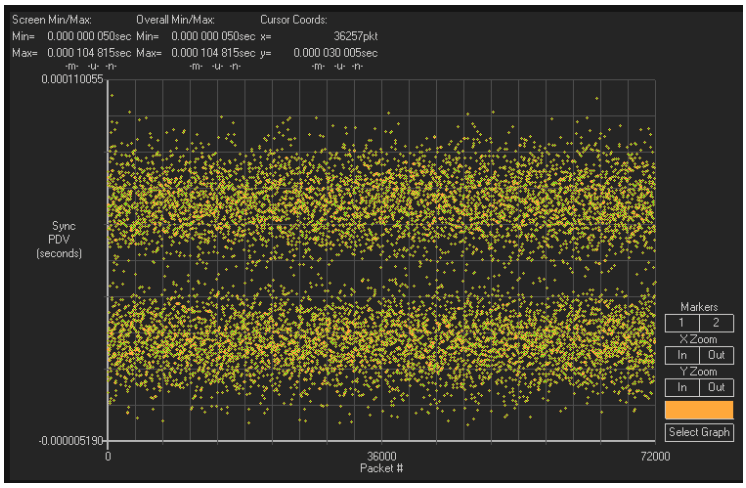


f. **Banding** – allows the packet timings to be gathered into bands or excluded from a band of timing.

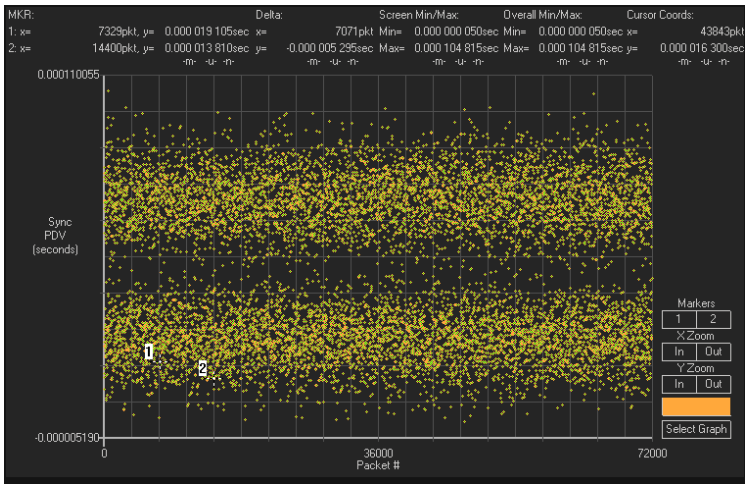
For a clearer view of the data it is recommended that the graph be viewed in scatter graph mode rather than line mode.

The scatter graph mode is selected using the ***Select Graph > Graph Format > Dot*** controls located at the right hand side of the graph display.

The scatter graph display for Testcase 12a 16pps is shown below.

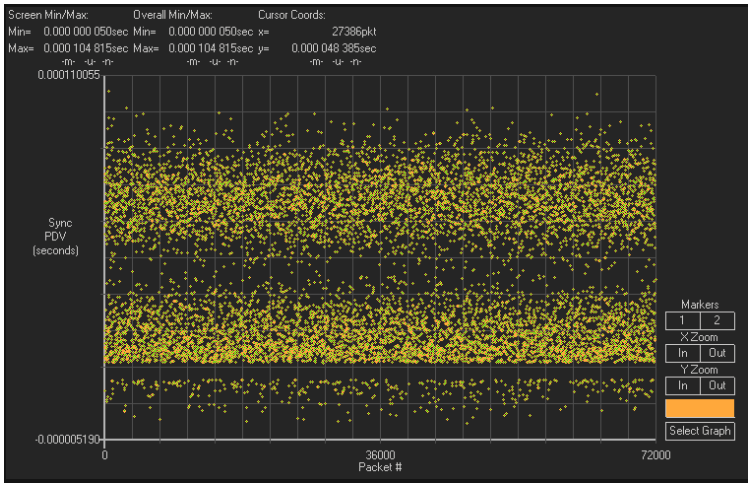


To define a band, the **Markers** are used. Note that they set the band in the **Y-axis**.



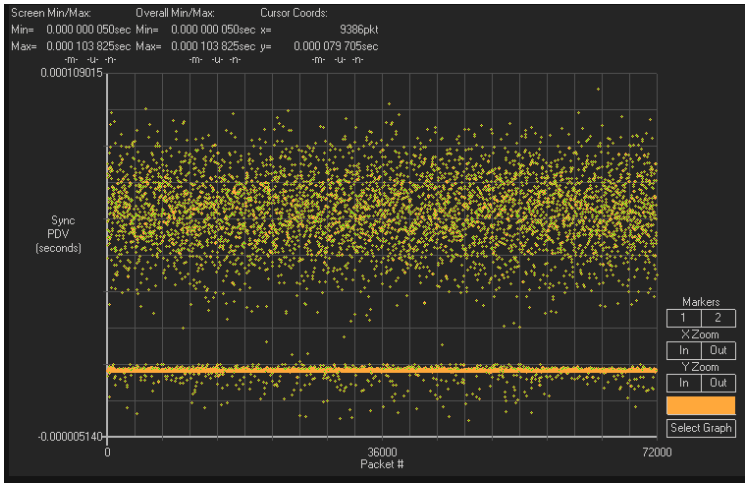
The data in the defined band may now be **depleted** or **concentrated**.

If ***Deplete > All*** is selected, the packets in the band are moved out by adding an offset equal to the band height to each of the packets to be moved as shown below.



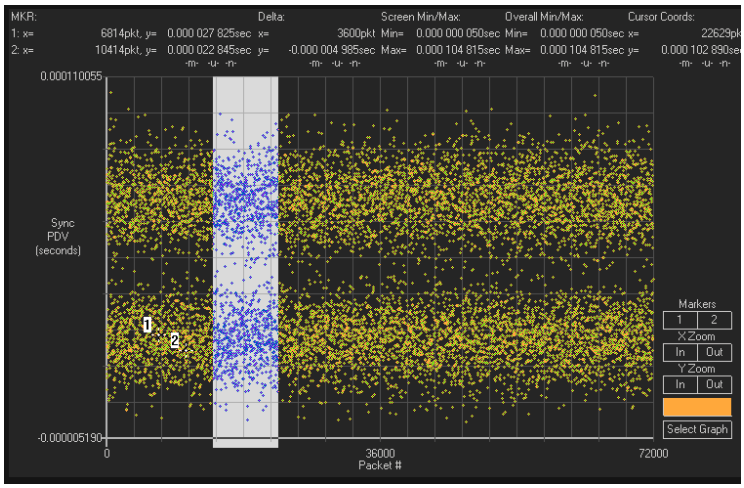
If ***Concentrate*** **>** ***All*** is selected, you will be prompted for a **percentage**. This is the percentage of all packets in the profile that will be concentrated into the band defined by the two markers.

The packets selected to be moved into the band are picked at random and given a randomised value within the band set. The result will be as shown below where **50%** of the packets have been concentrated into the define band.

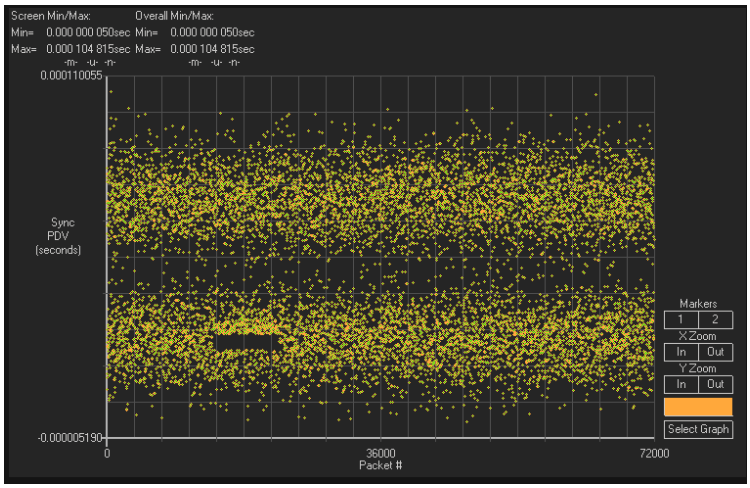


It is possible to apply the **Banding** over a section of the profile by **highlighting the X-axis range** over which the Depletion or Concentration is required.

For example the screenshot below shows the markers defining the band to be adjusted and the highlighting to define an X-axis section to be manipulated.



Resulting in the following when ***Deplete*** > ***Highlighted*** is selected.



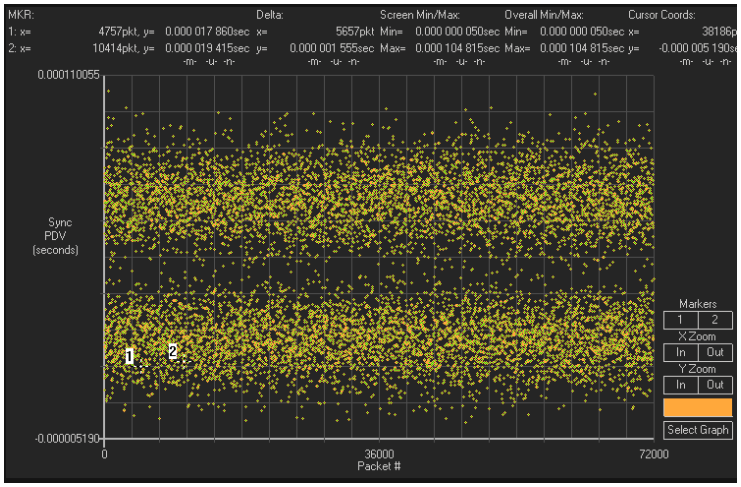
g. **Noise Floor Density** – allows the profile to be adjusted to change the density of packets to be found in the noise floor i.e. lucky packets.

There are two dimensions that can be defined. If only a limited section of the profile is required to be adjusted, then that section should be highlighted using the mouse click and drag as defined in the **Remove** section.

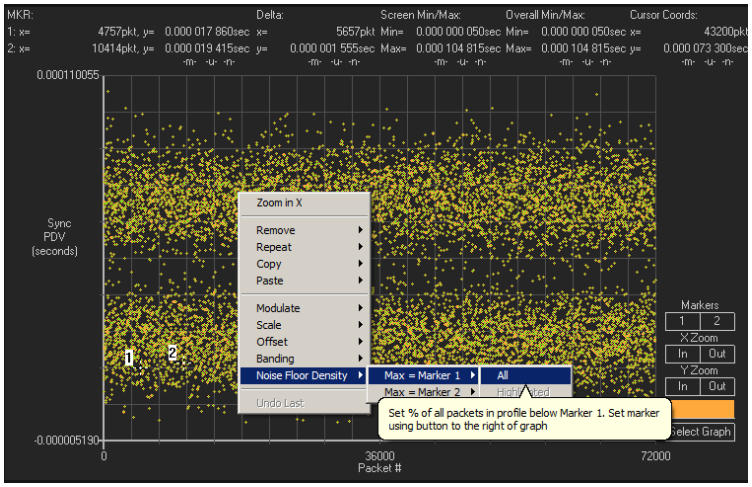
The band of interest is defined between the packet with the minimum delay and one of the markers. Based on the requested %, the number of desired packets within the noise band is then calculated.

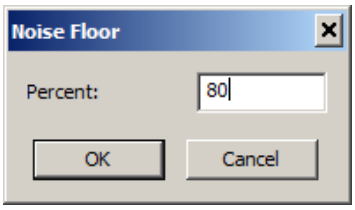
- If there are less packets than requested, packets out with the band are linearly selected and reassigned a new random value in between the marker and the minimum profile value.
- If there are more packets in the band than requested then packets within the band are linearly selected and offset by the difference between the marker and the minimum profile value.

Example 1: If you are making an adjustment across all of the packets, you need to define the top of the band using the marker (Marker 2 in this case). This is shown below.



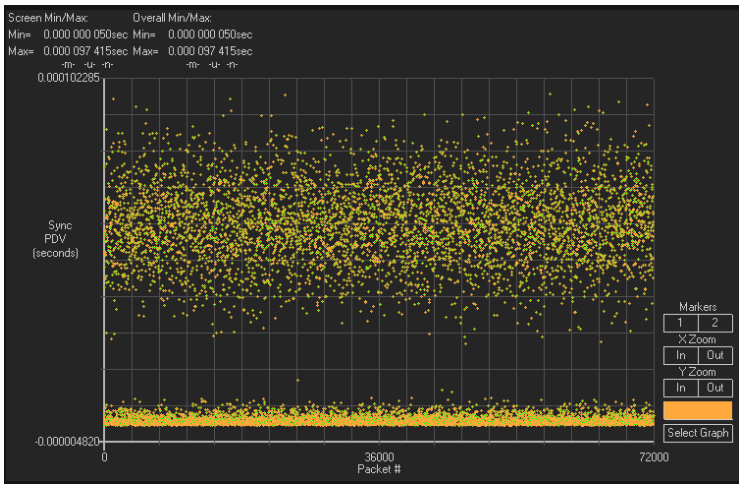
The Banding and the Marker are selected as shown below. Since there is no highlighting, the only choice is **All** i.e. across the whole set of packets.





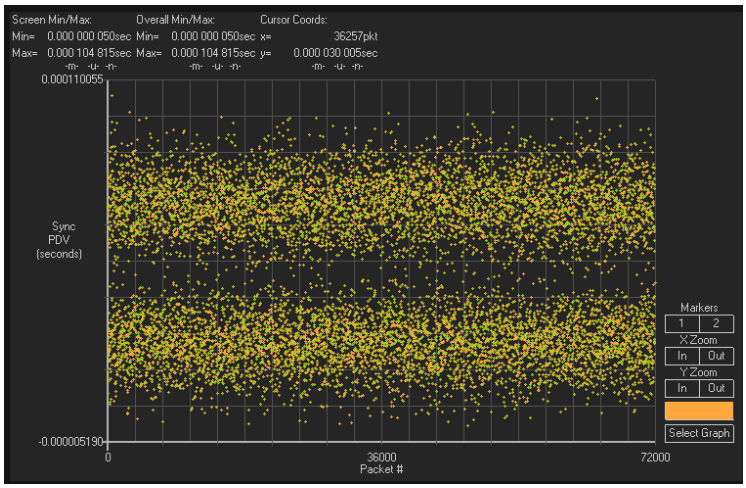
The percentage of packets to be placed in this band is now user-selectable via the pop-up screen.

The following shows the effect when 80% of the packets are moved into the band.

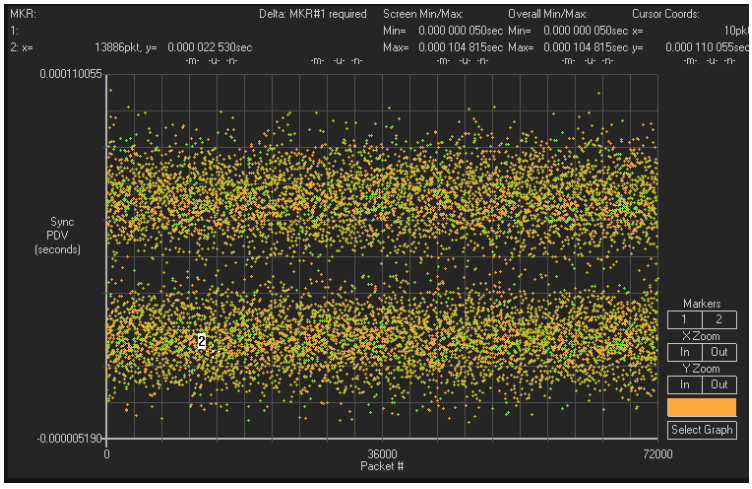


Example 2: Where the manipulation is applied over part of the packet set using the highlighting feature.

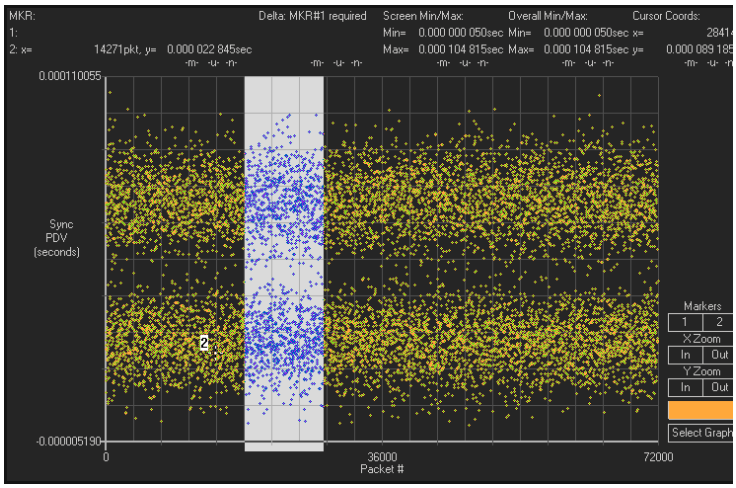
Initial data set is shown below.



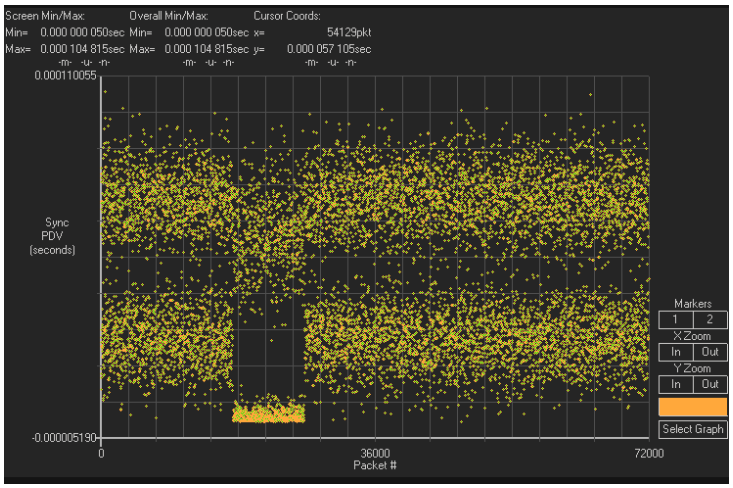
Set the marker.



Set the range of the area to be adjusted.



Apply the **Noise Floor Density** adjustment as described in Example 1, **Noise Floor Density, Max = Marker 2 , Highlighted**.

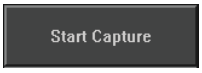


h. **Undo Last** – allows you to return to the data set prior to the last operation.

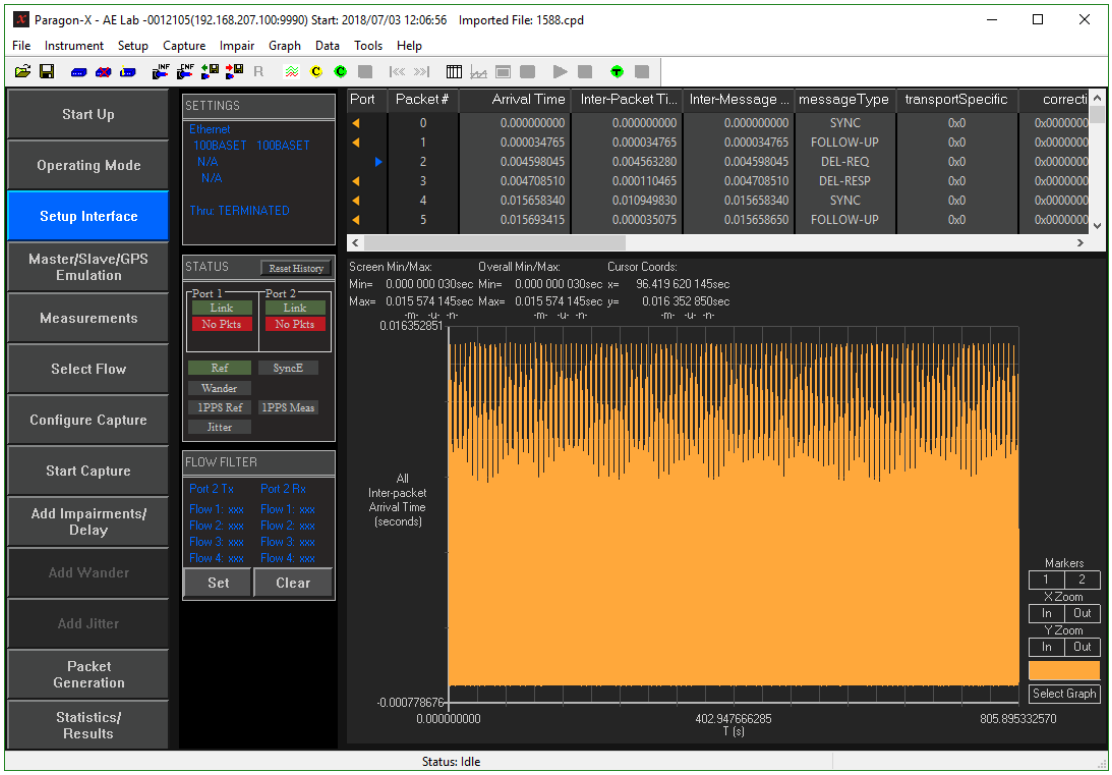
Note that several windows may be opened to allow cutting and pasting of parts of several profiles to provide a final composite data set for replay. This is invoked by using the ***File*** > ***Import*** selection from the application toolbar menu.

Appendix 2 – Raw Bytes decode of 1588 header

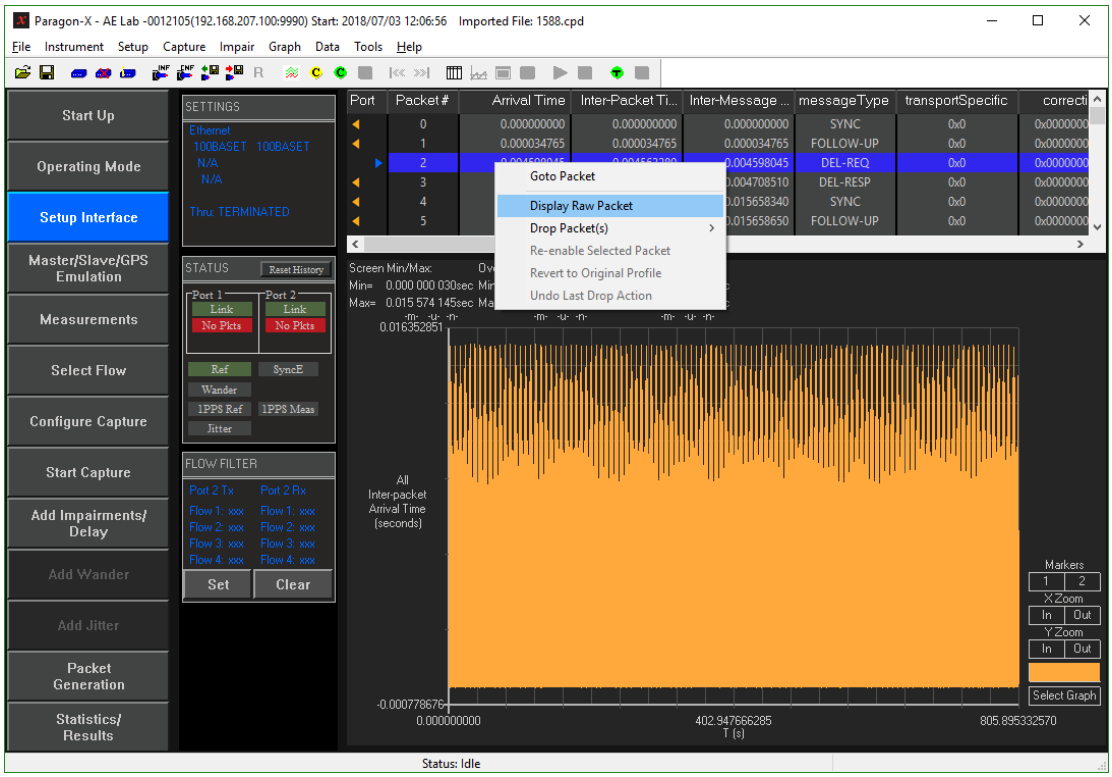
The raw bytes of the captured header which contains the Common Message header and the message specific fields can be viewed in a tabular format.

The data is captured using the 

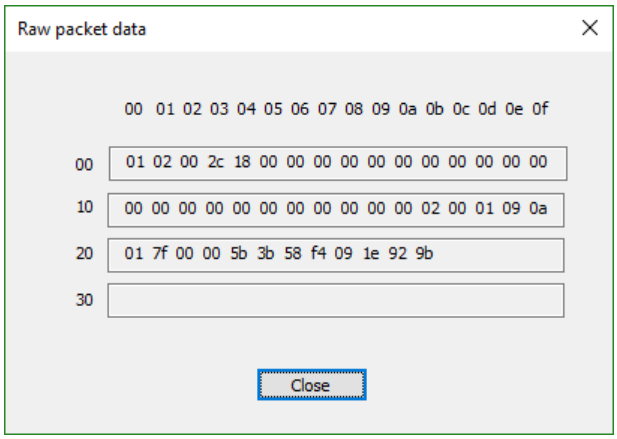
button, which will display the tabled and graphed results in the usual way:



To view a captured message in hexadecimal, left click the mouse on the table entry to highlight the desired packet, then right click to display the following menu:



Select the **Display Raw Packet** menu item to display the packet data:



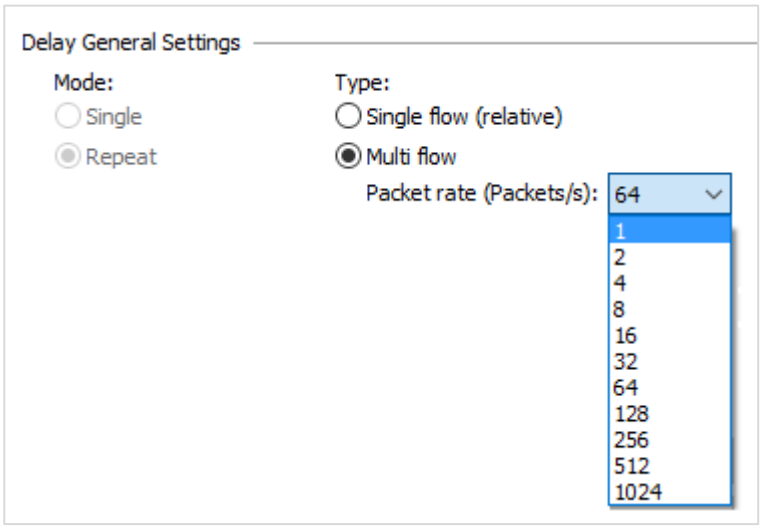
Appendix 3 – Multi-flow packet delays

Single-flow packet delay mode applies the specified delay profile (either generated or user-defined from a specified file) on a packet-by-packet basis to all packets that pass the selected filters.

Multi-flow delay insertion applies each delay value for a period defined by the user, so all packets in the multiple flows which pass the selected filters within this period will be affected by the same delay value. Once this configured time has passed, the next value from the profile is applied for the next period.

Both single-flow and multi-flow modes apply each packet delay relative to the inherent delay of the passing packet.

The fixed time period is specified in terms of the lowest packet rate for all the flows of interest, and is the reciprocal of the packet rate selected by the user. This ensures that each packet in the lowest rate stream will have a delay profile value applied.



Note: delays will only be applied to those flows and message types which have been configured using the Flow Filter as described in the **Applying Packet Delays** section.

Calnex Solutions Ltd
Oracle Campus
Linlithgow
EH49 7LR
United Kingdom

t: +44 (0) 1506 671 416
e: info@calnexsol.com

calnexsol.com

CX4008 v0.1 November 18