ZCU670 Multicast Boundary Clock Performance

Introduction

This report shows the results of Multicast Boundary Clock testing with the ZCU670 platform. Tests results are compared to the ITU-T G.8273.2 Full Time Support Standard.

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1. Overview

This report shows the results of Multicast Boundary Clock testing with the ZCU670 platform. Tests results are compared to the ITU-T G.8273.2 Full Time Support Standard. Noise generation tests measure the amount of noise produced at the output of the T-BC when there is an ideal input reference packet timing signal. The noise generation is measured on both the PTP and 1PPS outputs of the DUT. Holdover performance tests check holdover performance by measuring the phase/time output in the event of the loss of the PTP input to the T-BC. The holdover performance is measured on PTP and 1PPS outputs of the DUT.

2. Results Summary

Standard	Configuration	Test Case	Results
G.8273.2	Standalone (ts2phc, ptp4l, synced)	Noise Generation	**Pass**
		Holdover	**Pass**
		SyncE to PTP Noise Transfer	**Pass**
		SyncE to 1PPS Noise Transfer	**Pass**
		PTP to PTP Noise Transfer	**Pass**
		PTP to 1PPS Noise Transfer	**Pass**
		SyncE Transient	**Pass**
		G.8271.1 Reference Point C PDV	**Pass**
	External Servo (pcm4l, ptp4l, synced)	Noise Generation	**Pass**
		Holdover	**Pass**
		SyncE to PTP Noise Transfer	**Pass**
		SyncE to 1PPS Noise Transfer	**Pass**

3. Test Configuration

All tests in this report were completed using a boundary clock configuration as this tests both the **timeReceiver** and **timeTransmitter** functions.

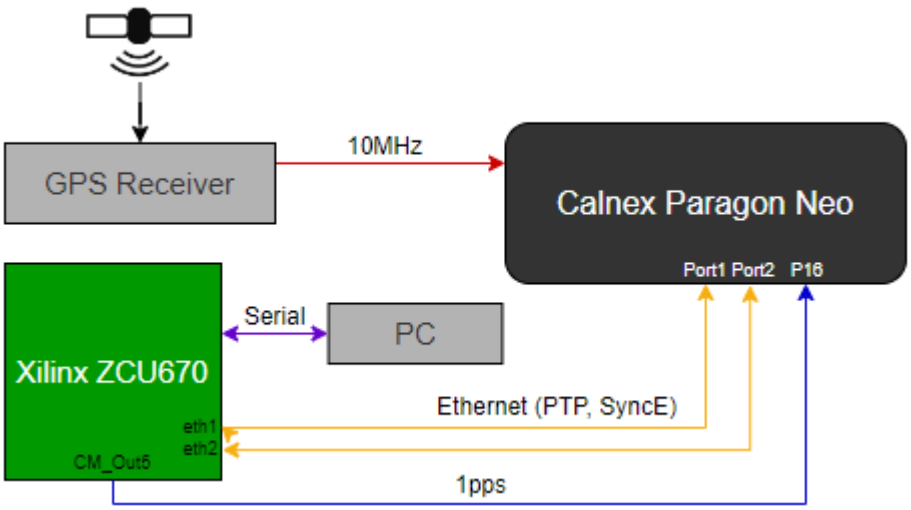


Figure 1. Equipment Configuration

4. Standalone Tests (ts2phc, ptp4l, synced)

4.1 G.8273.2: Noise Generation

The noise generation of a T-BC represents the amount of noise produced at the output of the T-BC when there is an ideal input reference packet timing signal. The noise generation is measured on both the PTP and 1PPS outputs of the DUT.

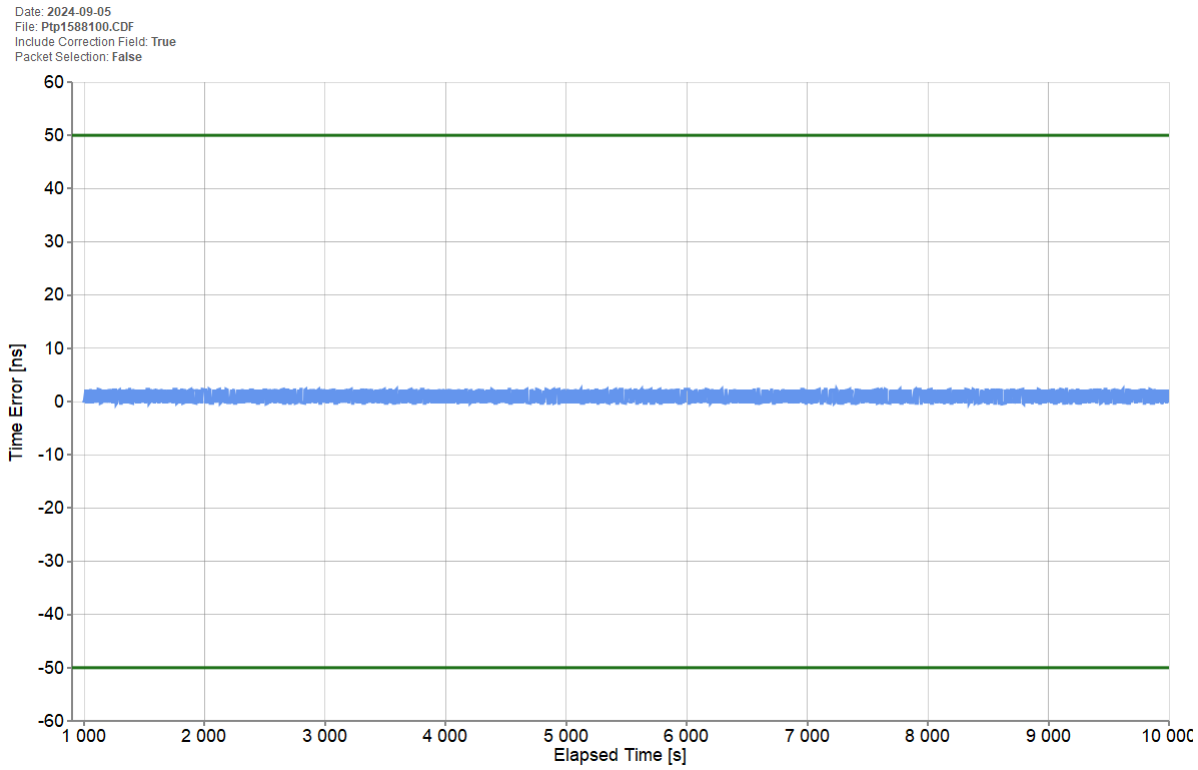
In this section, the standalone configuration (ts2phc, ptp4l, synced) is tested for conformance to ITU-T G.8273.2 Section 7.1 Class D. Physical layer assistance (SyncE) is used during this test.

4.1.1 PTP Measurements

Test Description	Noise Generation
Report Date	24-09-06_12-21-02
Packet Rate (pkt/s)	16
Beginning of Test	9/5/2024 1:00:56 PM
Test Duration	02:57:49

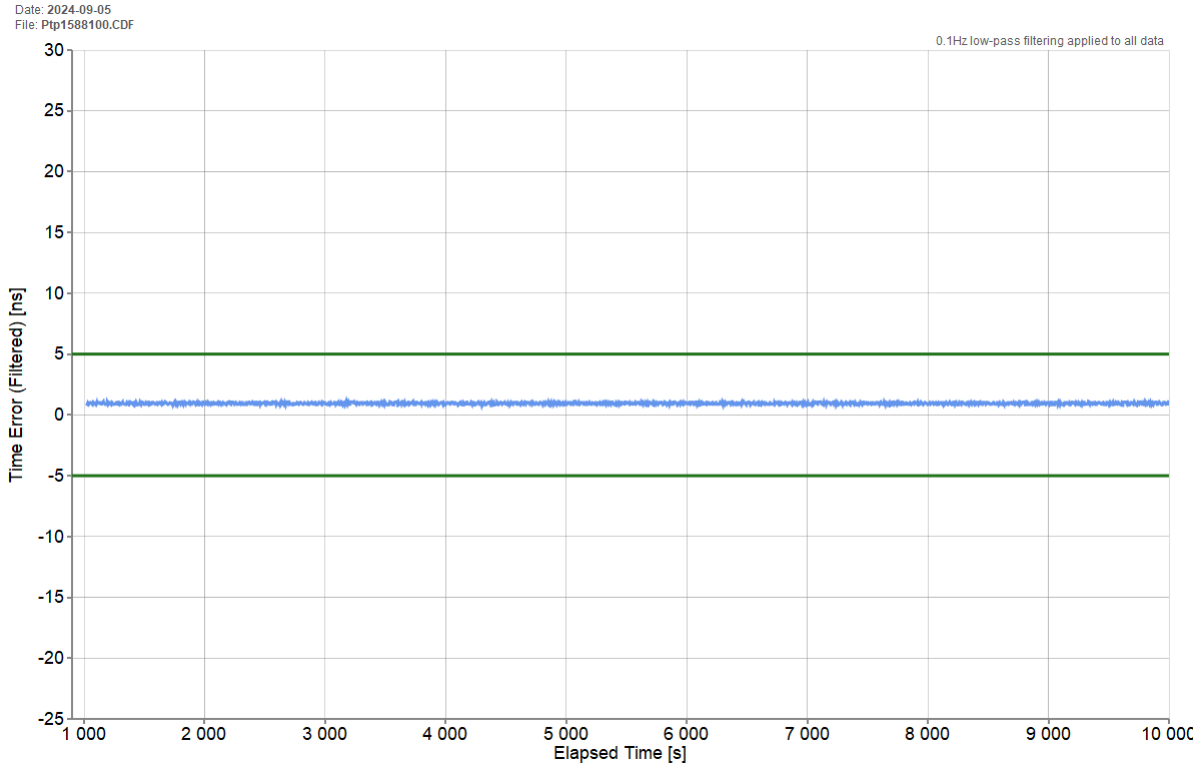
All Mask Results	**Pass**
Mask TIMEERROR	0.05µs
Mask TIMEERROR Result	**Pass**
Mask FILTEREDTIMEERROR	0.005µs
Mask FILTEREDTIMEERROR Result	**Pass**
Mask CTE	0.01µs
Mask CTE Result	**Pass**
Mask DTE	0.01µs
Mask DTE Result	**Pass**
Mask DTEHF	0.07µs
Mask DTEHF Result	**Pass**
Mask DTEMTIE	G.8273.2 T-BC Class C Dynamic TE LF Const. Temp.
Mask DTEMTIE Result	**Pass**
Mask DTETDEV	G.8273.2 T-BC Class C Dynamic TE LF Const. Temp.
Mask DTETDEV Result	**Pass**

4.1.1.1 TIMEERROR Analysis



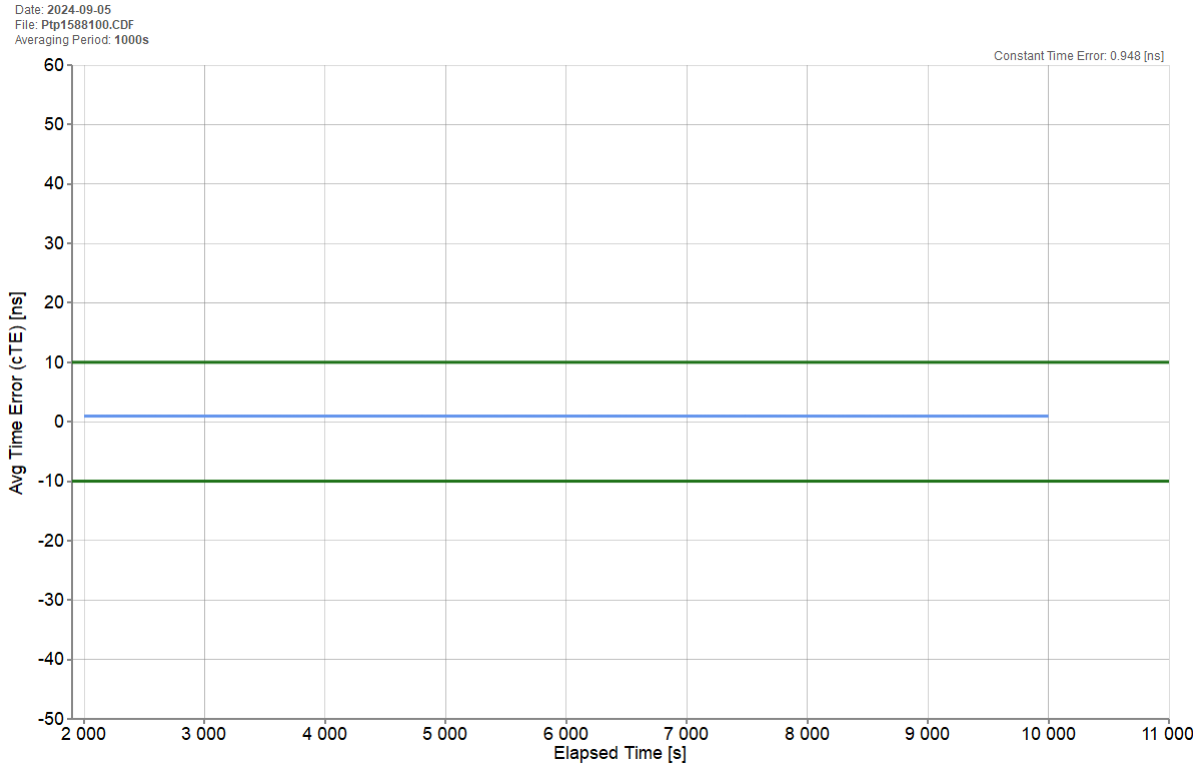
Pk-Pk [ns]	2.75
Mean [ns]	0.948
Min [ns]	-0.452
Max [ns]	2.298

4.1.1.2 FILTEREDTIMEERROR Analysis



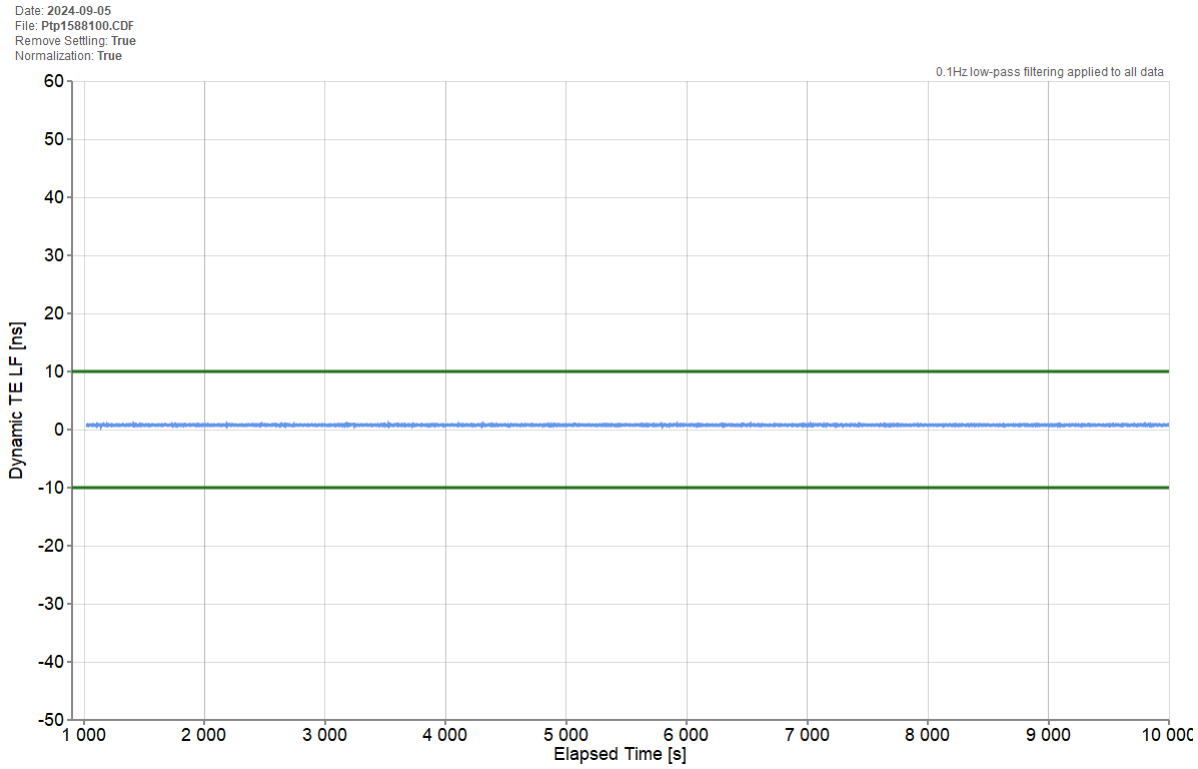
Mean [ns]	0.948
Min [ns]	0.758
Max [ns]	1.169
Max-Min [ns]	0.41

4.1.1.3 CTE Analysis



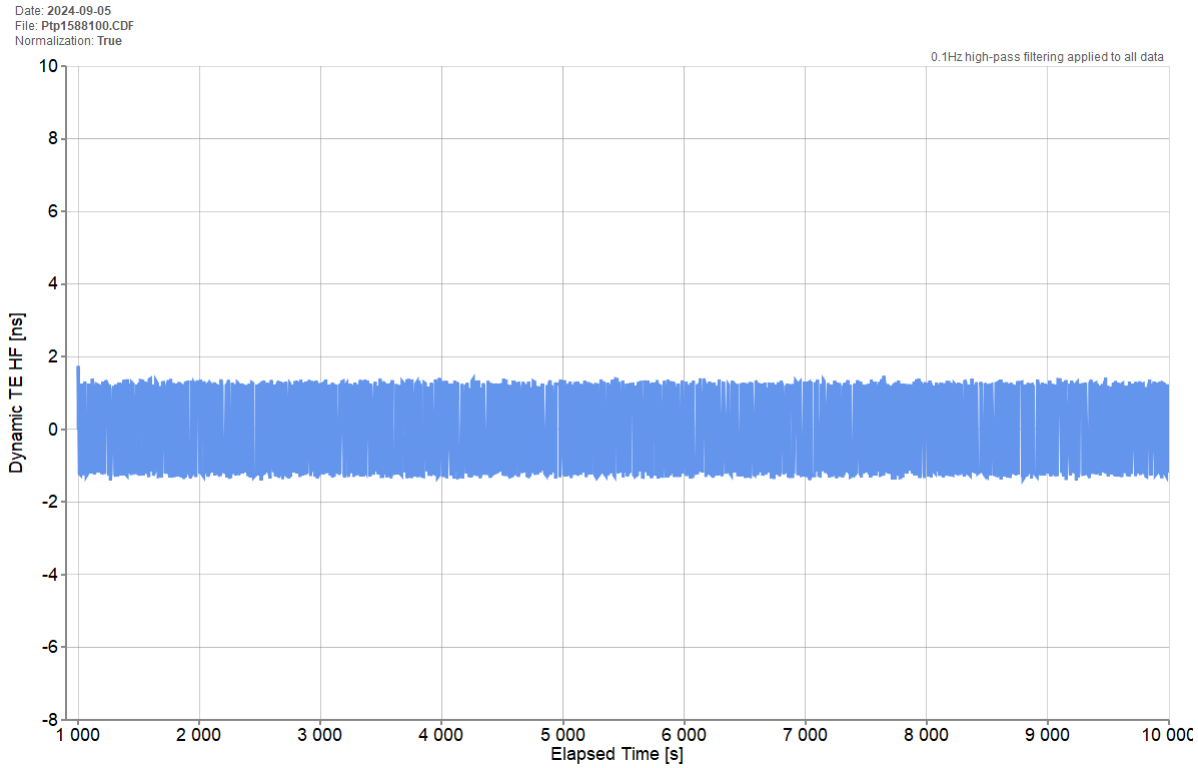
Averaging Time (s)	1000
Constant Time Error [ns]	0.948
Min [ns]	0.943
Max [ns]	0.953
Max-Min [ns]	0.01

4.1.1.4 DTE Analysis



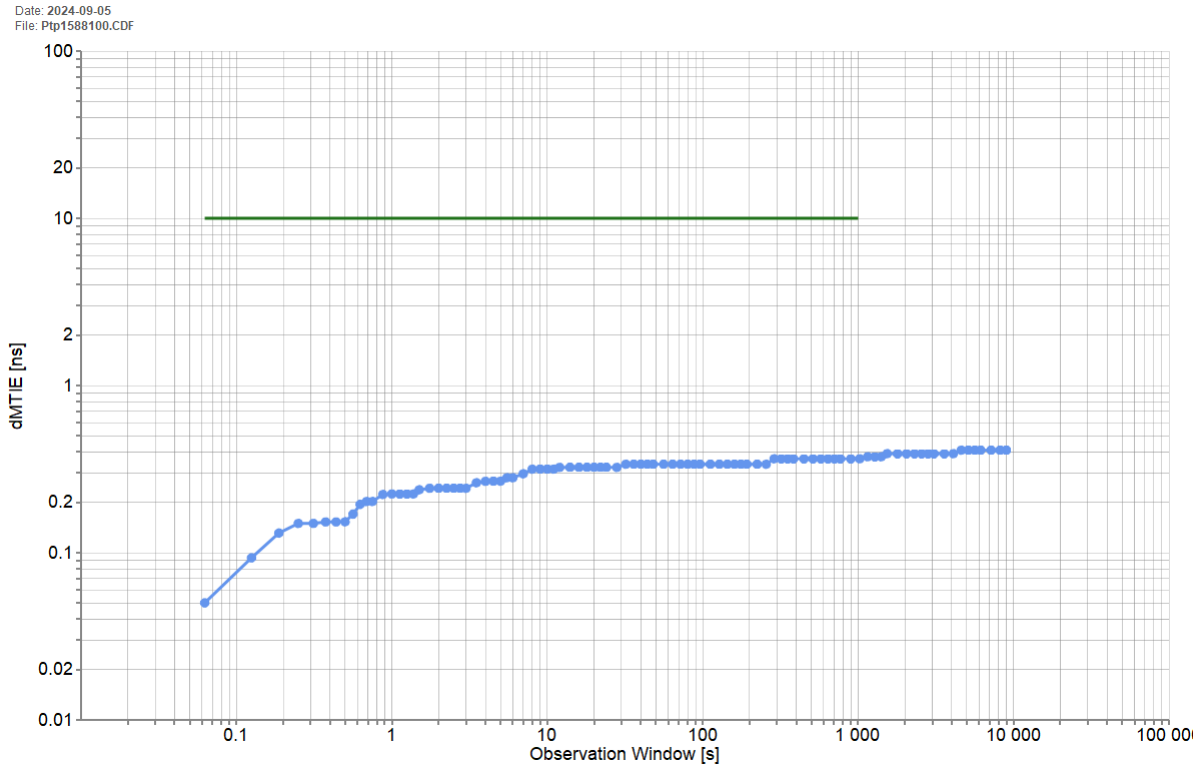
Mean [ns]	0.775
Min [ns]	0.585
Max [ns]	0.996
Max-Min [ns]	0.41

4.1.1.5 DTEHF Analysis



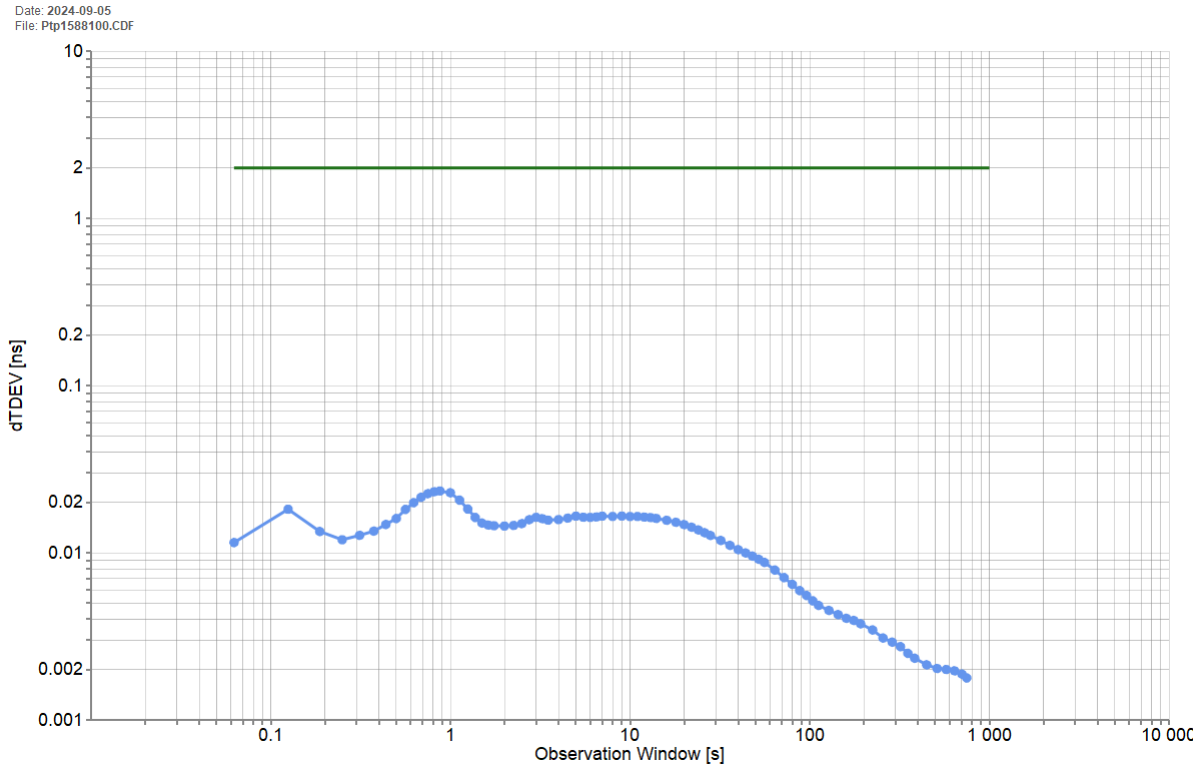
Pk-Pk [ns]	3.153
Mean [ns]	0
Min [ns]	-1.412
Max [ns]	1.741

4.1.1.6 DTEMTIE Analysis



Min [ns]	0.05
Max [ns]	0.41
Max-Min [ns]	0.36

4.1.1.7 DTETDEV Analysis



Min [ns]	0.002
Max [ns]	0.023
Max-Min [ns]	0.022

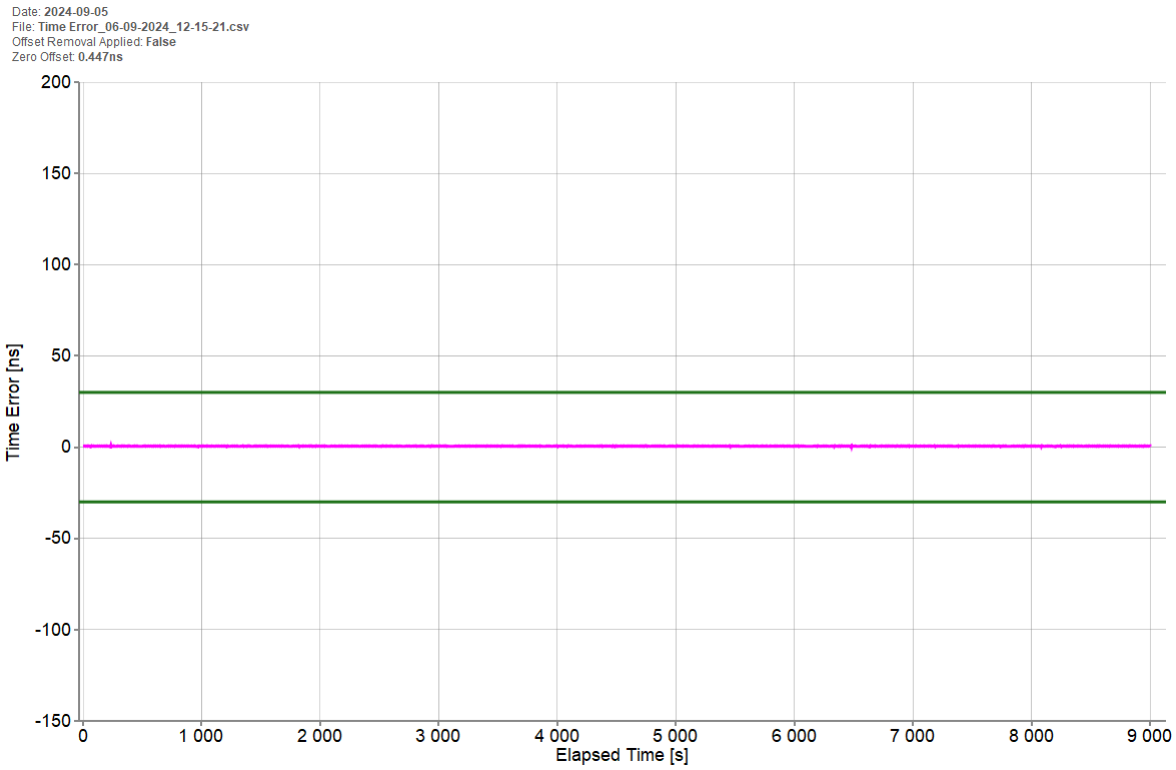
4.1.2 1PPS Measurements

Test Description	Noise Generation
Report Date	24-09-06_12-21-02
Packet Rate (pkt/s)	16
Beginning of Test	9/5/2024 1:00:58 PM
Test Duration	02:30:00

All Mask Results	**Pass**
Mask ONEPPS	0.03µs
Mask ONEPPS Result	**Pass**
Mask FILTEREDTIMEERROR	0.005µs
Mask FILTEREDTIMEERROR Result	**Pass**
Mask CTE	0.01µs
Mask CTE Result	**Pass**
Mask DTE	0.01µs
Mask DTE Result	**Pass**
Mask DTEHF	0.07µs
Mask DTEHF Result	**Pass**
Mask DTEMTIE	G.8273.2 T-BC Provisional Class D Dynamic TE LF Const. Temp.
Mask DTEMTIE Result	**Pass**
Mask DTETDEV	G.8273.2 T-BC Provisional Class D Dynamic TE LF Const. Temp.
Mask DTETDEV Result	**Pass**

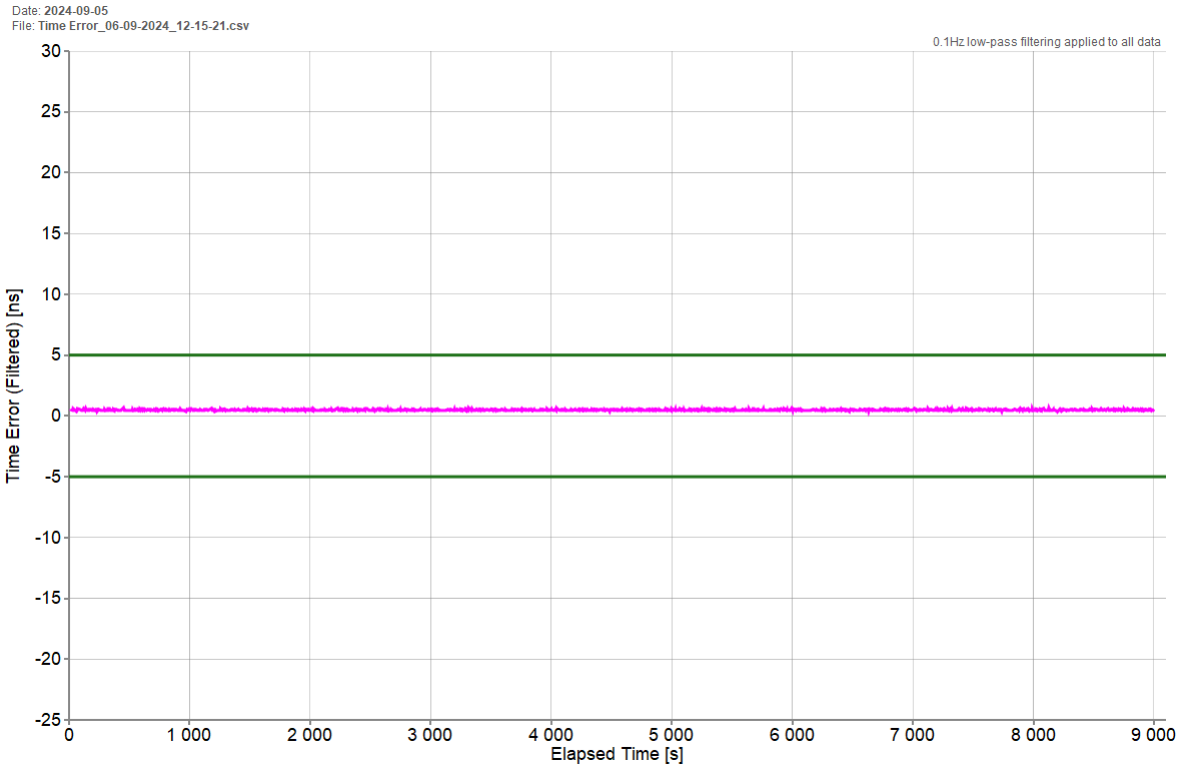
4.1.2.1 ONEPPS Analysis

Offset Removal Applied	Off
Zero Offset	0.447 ns



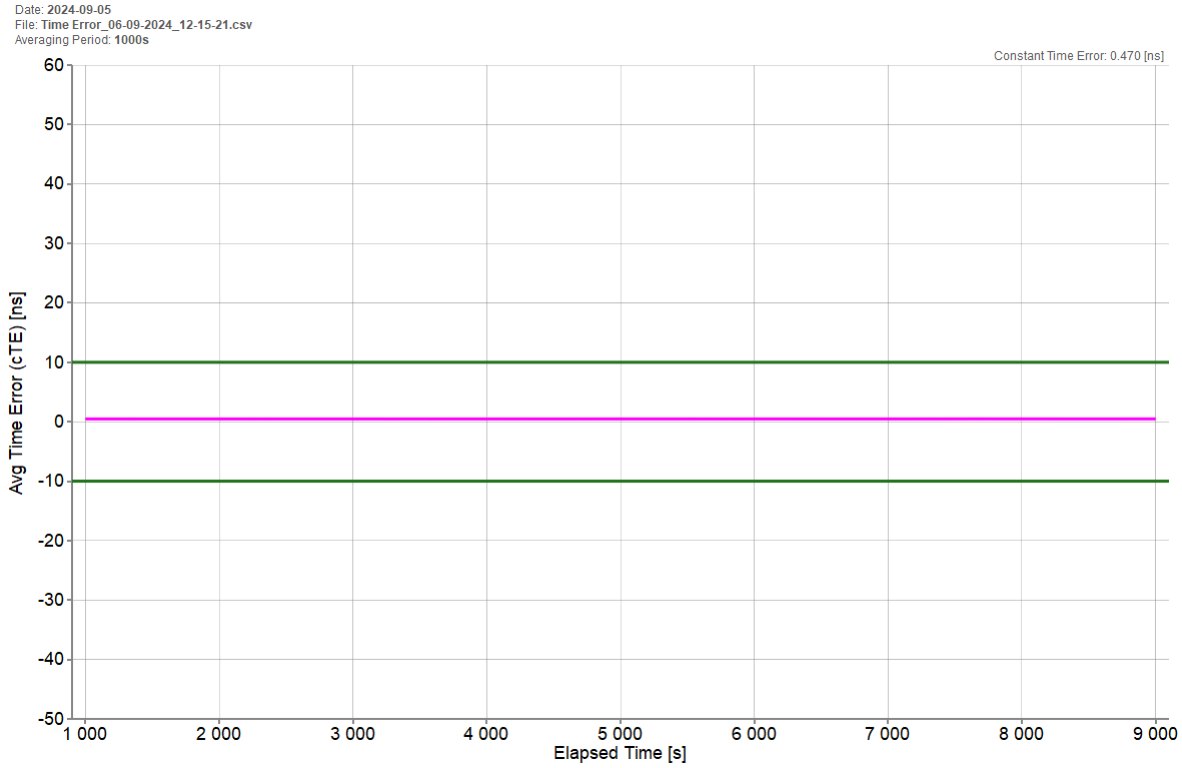
Mean [ns]	0.47
Min [ns]	0.197
Max [ns]	0.697
Max-Min [ns]	0.5

4.1.2.2 FILTEREDTIMEERROR Analysis



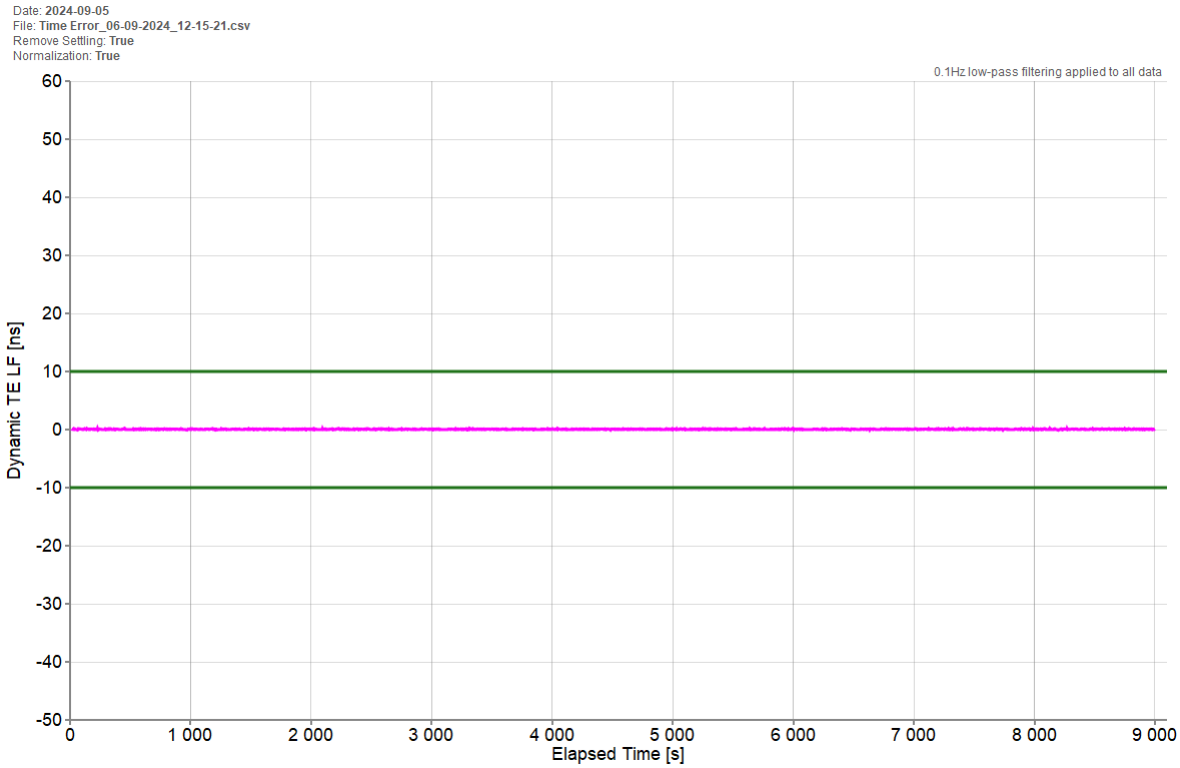
Mean [ns]	0.47
Min [ns]	0.354
Max [ns]	0.673
Max-Min [ns]	0.319

4.1.2.3 CTE Analysis



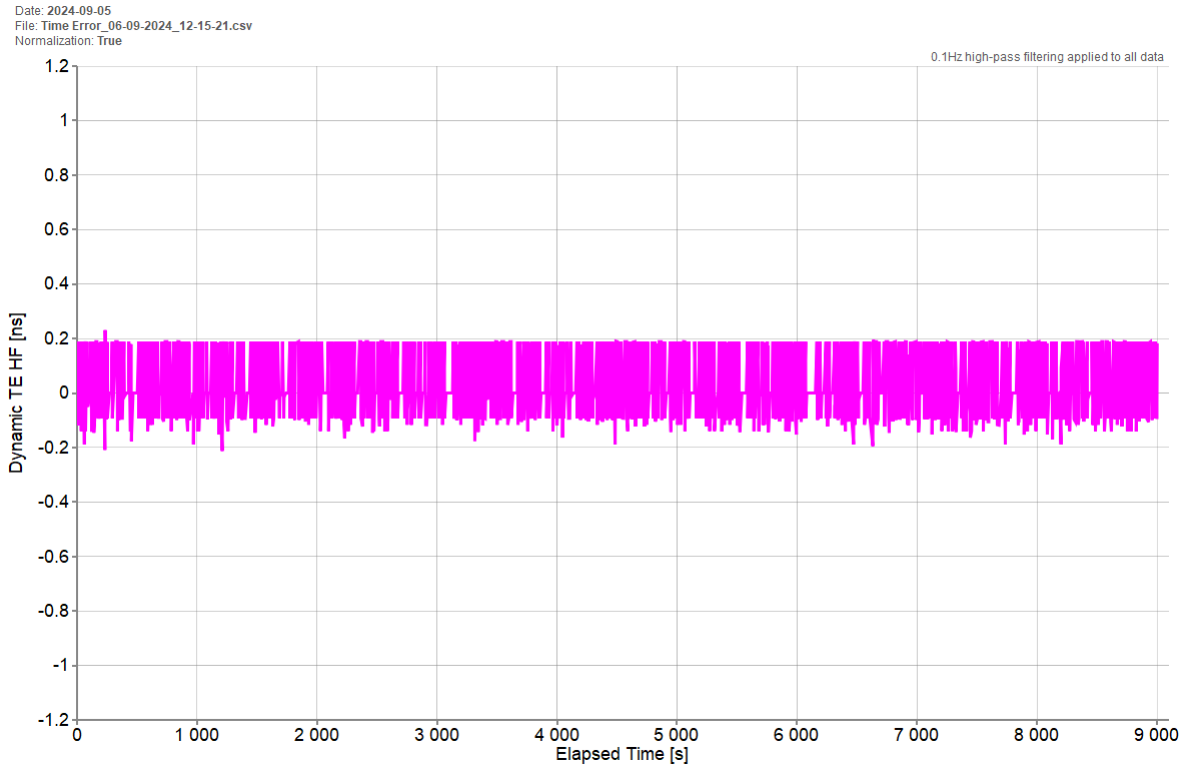
Averaging Time (s)	1000
Constant Time Error [ns]	0.47
Min [ns]	0.465
Max [ns]	0.478
Max-Min [ns]	0.013

4.1.2.4 DTE Analysis



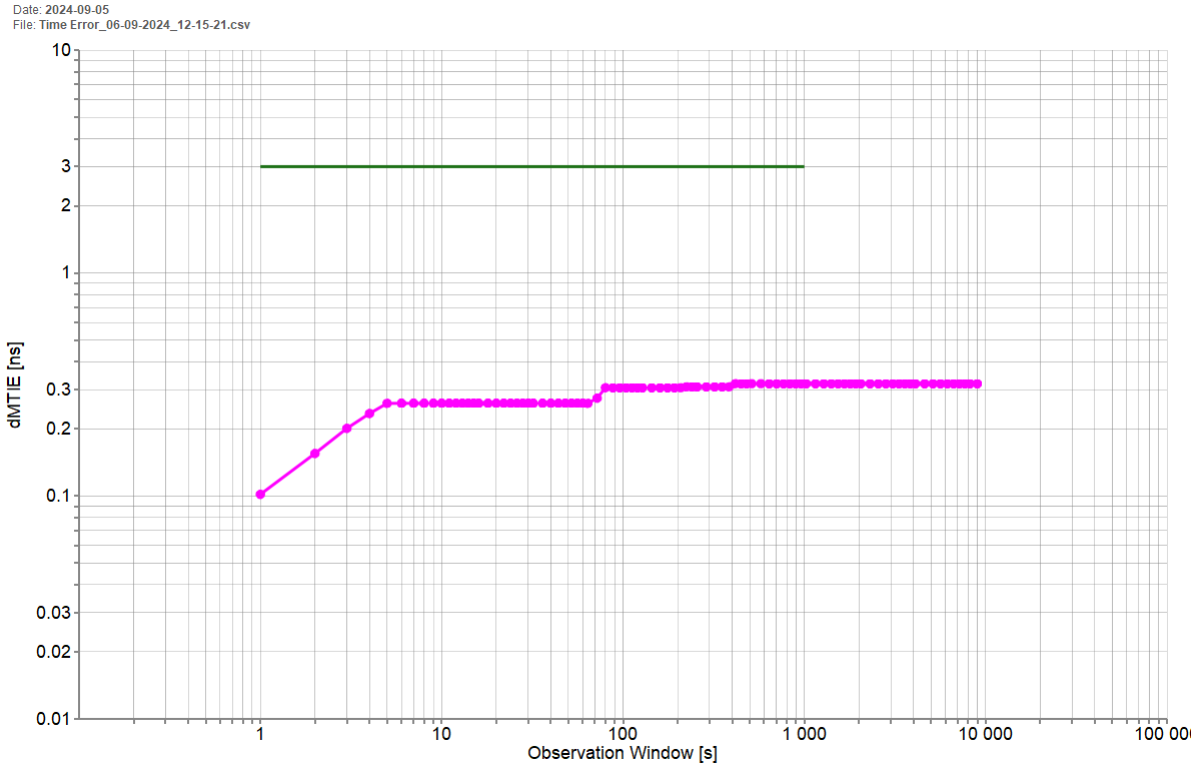
Mean [ns]	0.023
Min [ns]	-0.093
Max [ns]	0.226
Max-Min [ns]	0.319

4.1.2.5 DTEHF Analysis



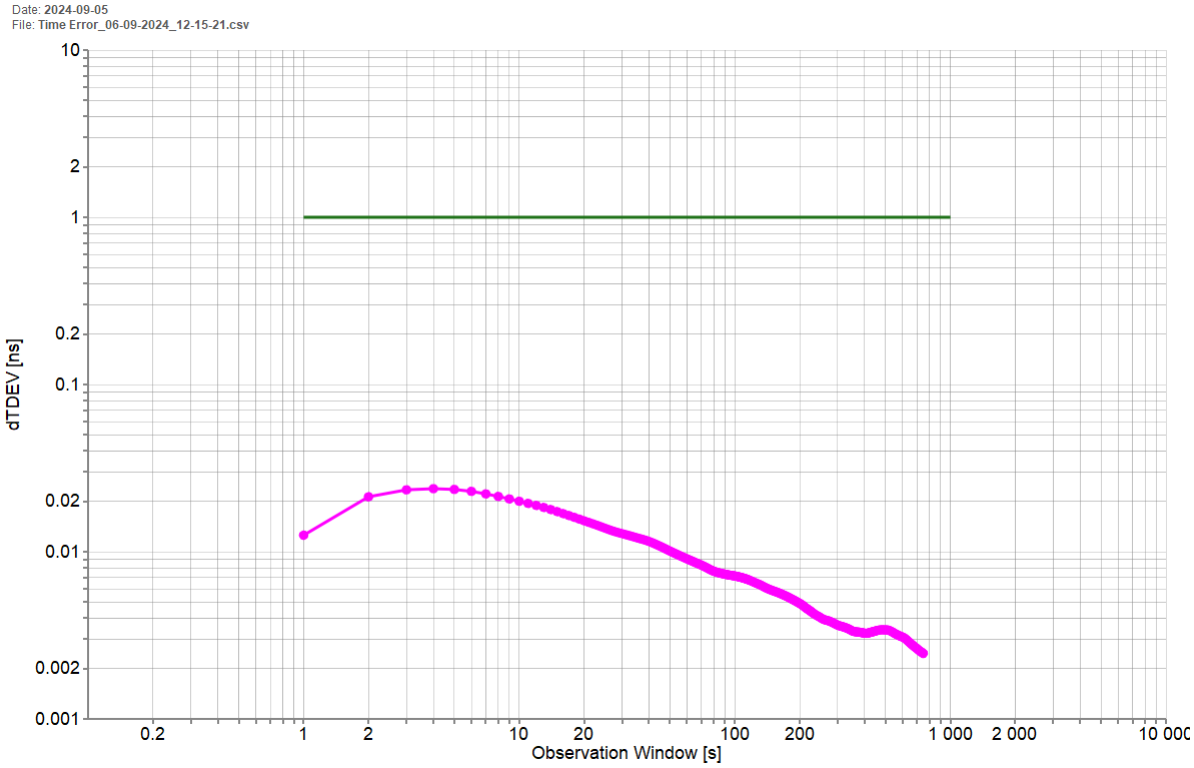
Mean [ns]	0
Min [ns]	-0.213
Max [ns]	0.231
Max-Min [ns]	0.443

4.1.2.6 DTEMTIE Analysis



Min [ns]	0.102
Max [ns]	0.319
Max-Min [ns]	0.217

4.1.2.7 DTETDEV Analysis



Min [ns]	0.002
Max [ns]	0.024
Max-Min [ns]	0.021

4.2 G.8273.2: Holdover

Holdover performance is checked by measuring the phase/time output in the event of the loss of the PTP input to the T-BC. The holdover performance is measured on PTP and 1PPS outputs of the DUT.

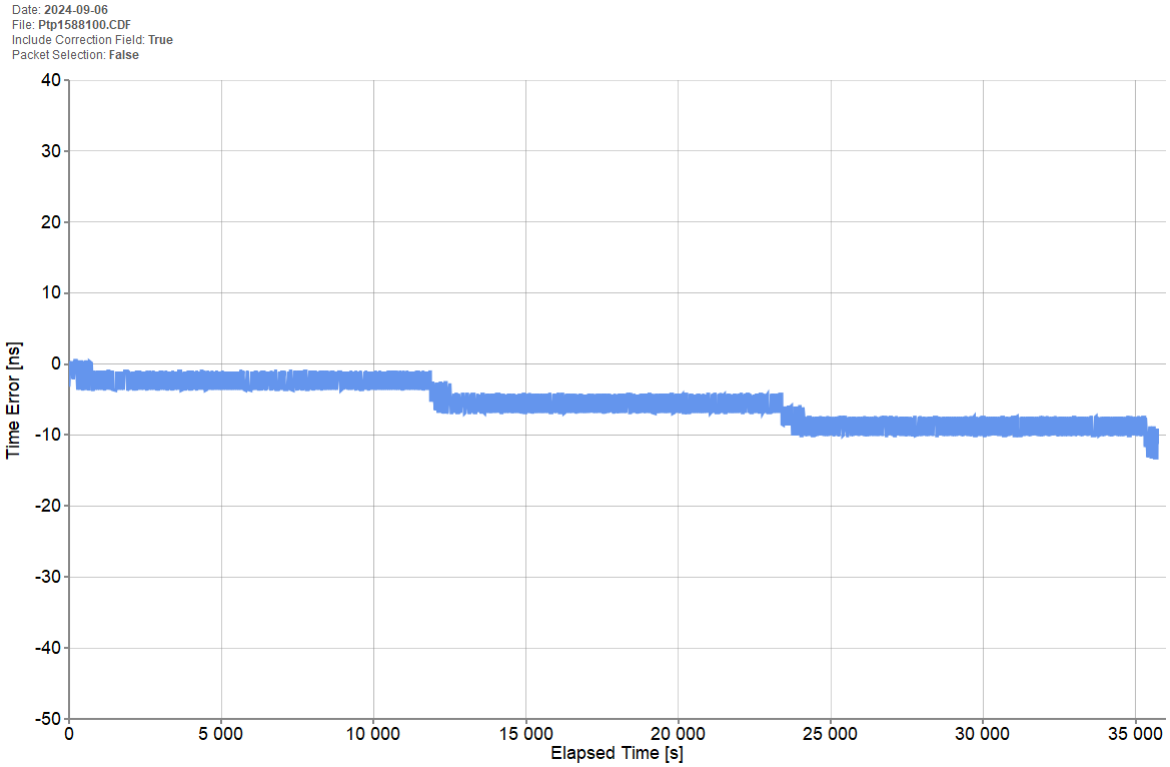
In this section, the standalone configuration (ts2phc, ptp4l, synced) is tested for conformance to ITU-T G.8273.2 Section 7.4.2.2 Class B. Physical layer assistance (SyncE) is used during this test.

4.2.1 PTP Measurements

Test Description	Holdover
Report Date	24-09-06_12-21-02
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 1:53:32 AM
Test Duration	09:55:12

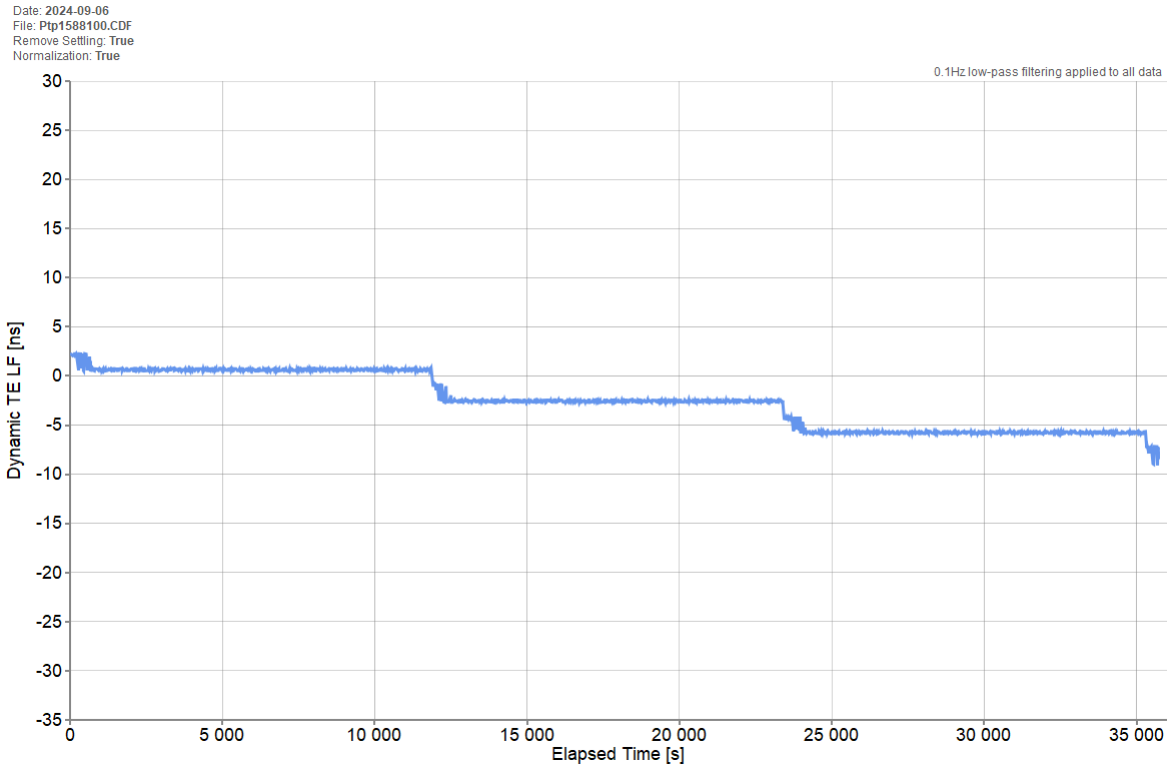
All Mask Results	**Pass**
Mask TIMEERROR	N/A
Mask TIMEERROR Result	NoMask
Mask DTE	N/A
Mask DTE Result	NoMask
Mask DTEMTIE	G.8273.2 T-BC Class B Time Holdover Const. Temp.
Mask DTEMTIE Result	**Pass**

4.2.1.1 TIMEERROR Analysis



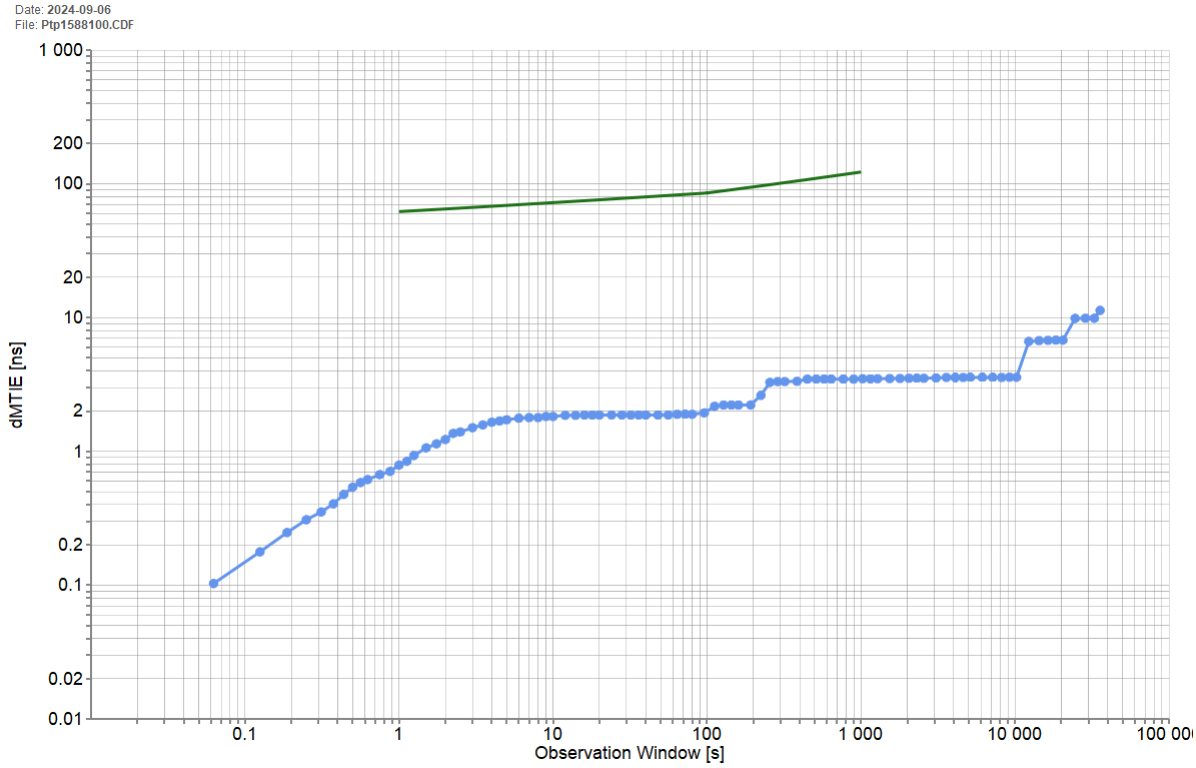
Pk-Pk [ns]	13.75
Mean [ns]	-5.548
Min [ns]	-13.237
Max [ns]	0.513

4.2.1.2 DTE Analysis



Mean [ns]	-2.562
Min [ns]	-9.065
Max [ns]	2.261
Max-Min [ns]	11.326

4.2.1.3 DTEMTIE Analysis



Min [ns]	0.103
Max [ns]	11.326
Max-Min [ns]	11.223

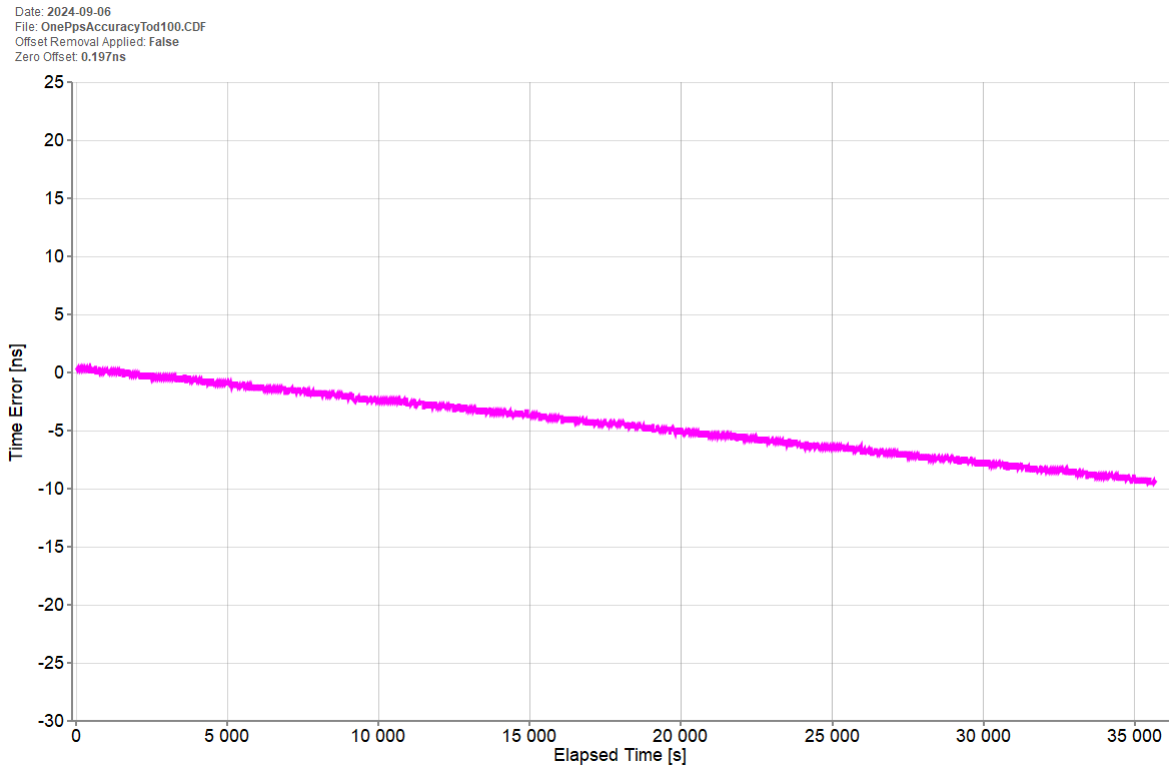
4.2.2 1PPS Measurements

Test Description	Holdover
Report Date	24-09-06_12-21-02
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 1:53:32 AM
Test Duration	09:55:10

All Mask Results	**Pass**
Mask ONEPPS	N/A
Mask ONEPPS Result	NoMask
Mask MTIE	G.8273.2 T-BC Class B Time Holdover Const. Temp.
Mask MTIE Result	**Pass**

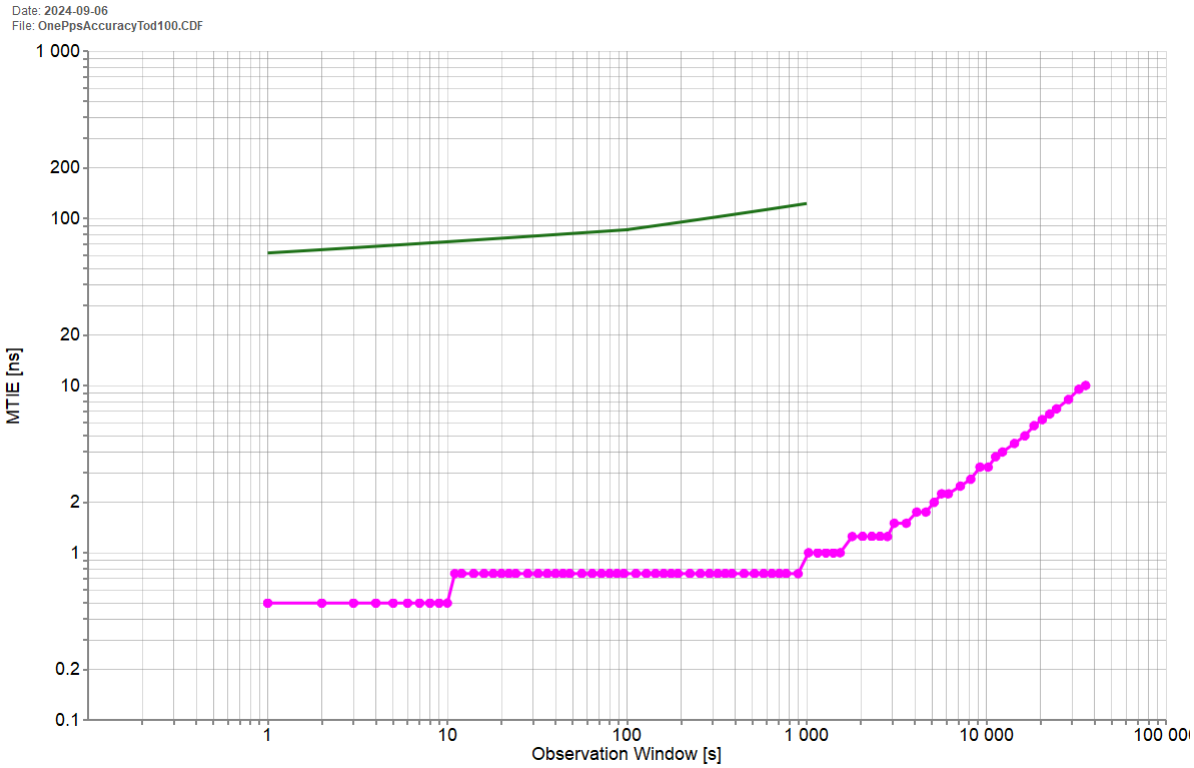
4.2.2.1 ONEPPS Analysis

Offset Removal Applied	Off
Zero Offset	0.197 ns



Mean [ns]	-4.563
Min [ns]	-9.553
Max [ns]	0.447
Max-Min [ns]	10

4.2.2.2 MTIE Analysis



Min [ns]	0.5
Max [ns]	10
Max-Min [ns]	9.5

4.3 G.8273.2: SyncE to PTP Noise Transfer

According to ITU-T G.8273.2 Section 7.3.3, the output PTP signal and 1 PPS signal must correspond to the input physical layer frequency input signal on which a band-pass filter whose lower corner frequency is between 0.05Hz and 0.1Hz and whose upper corner frequency is between 1Hz and 10Hz has been applied. This test checks whether T-BC under evaluation meets this bandpass filter requirement by adding sinusoidal noise on the SyncE (physical layer) input and measuring the output PTP noise amplitude.

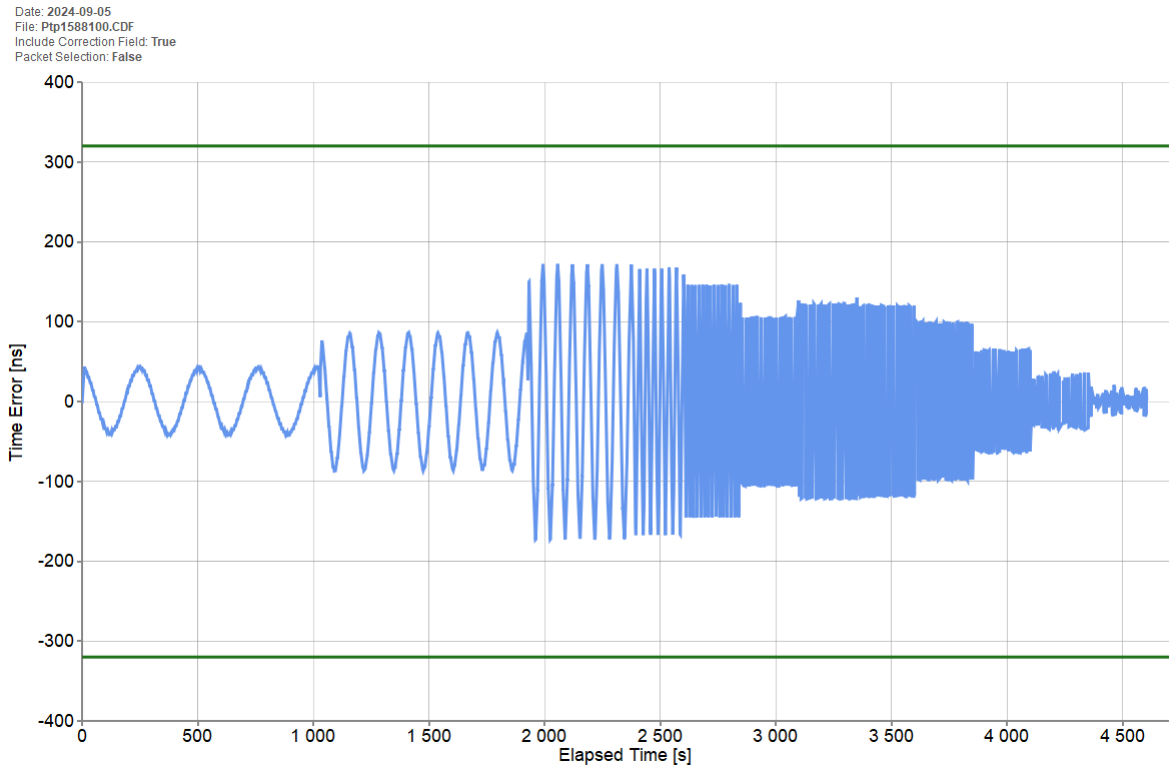
In this section, the standalone configuration (ts2phc, ptp4l, synced) with physical later assistance (SyncE) is tested for conformance to the Class C standard.

4.3.1 PTP Measurements

Test Description	SyncE To PTP Noise Transfer
Report Date	24-09-06_12-21-02
Packet Rate (pkt/s)	16
Beginning of Test	9/5/2024 7:31:49 PM
Test Duration	01:16:43

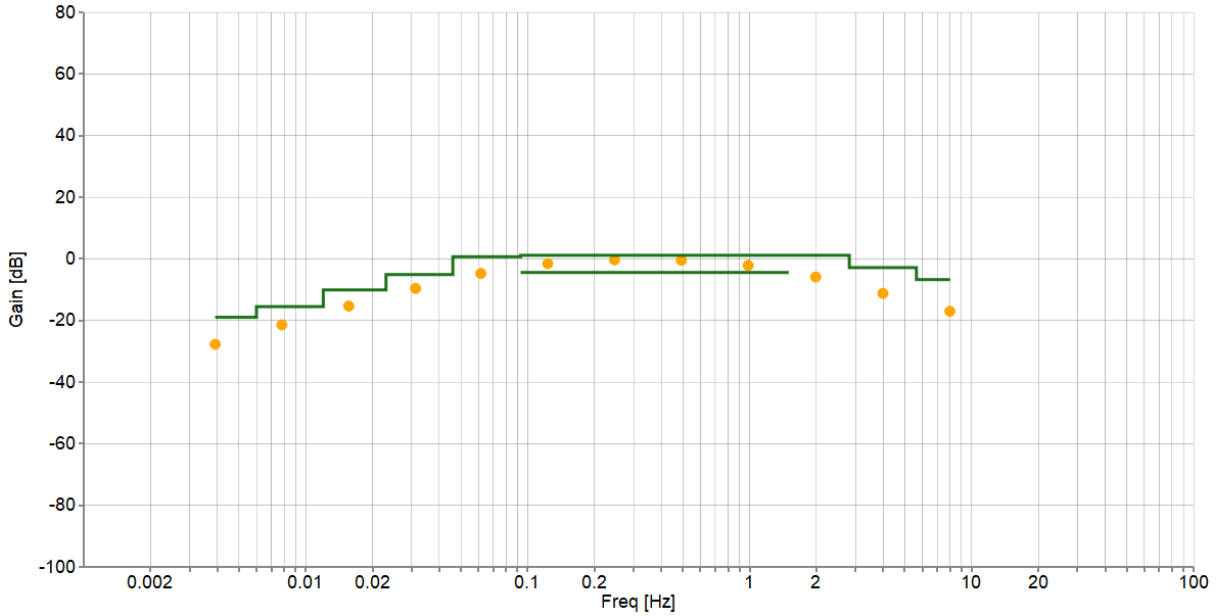
All Mask Results	**Pass**
Mask TIMEERROR	0.32µs
Mask TIMEERROR Result	**Pass**
Mask SyncENoiseTransfer	G.8273.2 Class C T-BCs Noise Transfer
Mask SyncENoiseTransfer Result	**Pass**

4.3.1.1 TIMEERROR Analysis



Pk-Pk [ns]	345.25
Mean [ns]	0.356
Min [ns]	-173.07
Max [ns]	172.18

4.3.1.2 SyncENoiseTransfer Analysis



Point #	Freq (Hz)	Ampl (ns)	Duration (s)	Pk-Pk Output (ns)	Gain (dB)	Upper Pk-Pk Limit (ns)	Lower Pk-Pk Limit (ns)
1	0.00391	2000	1023.02	82.02	-27.74	**225**	-
2	0.00781	2000	896.29	169.53	-21.44	**340**	-
3	0.01563	2000	447.86	341.05	-15.36	**630**	-
4	0.03125	1000	224.00	331.05	-9.60	**565**	-
5	0.06156	500	243.66	288.80	-4.77	**545**	-
6	0.12313	250	251.77	208.66	-1.57	**285**	**150**
7	0.24625	250	251.78	240.75	-0.33	**285**	**150**
8	0.4925	250	249.75	236.57	-0.48	**285**	**150**
9	0.985	250	249.75	194.96	-2.16	**285**	**150**
10	1.985	250	249.87	126.63	-5.91	**285**	-
11	3.985	250	249.94	68.75	-11.21	**285**	-
12	7.985	250	249.97	35.13	-17.05	**285**	-

4.4 G.8273.2: SyncE to 1PPS Noise Transfer

According to ITU-T G.8273.2 Section 7.3.3, the output 1PPS signal and 1 PPS signal must correspond to the input physical layer frequency input signal on which a band-pass filter whose lower corner frequency is between 0.05Hz and 0.1Hz and whose upper corner frequency is between 1Hz and 10Hz has been applied. This test checks whether T-BC under evaluation meets this bandpass filter requirement by adding sinusoidal noise on the SyncE (physical layer) input and measuring the output 1PPS noise amplitude.

In this section, the standalone configuration (ts2phc, ptp4l, synced) with physical later assistance (SyncE) is tested for conformance to the class C standard.

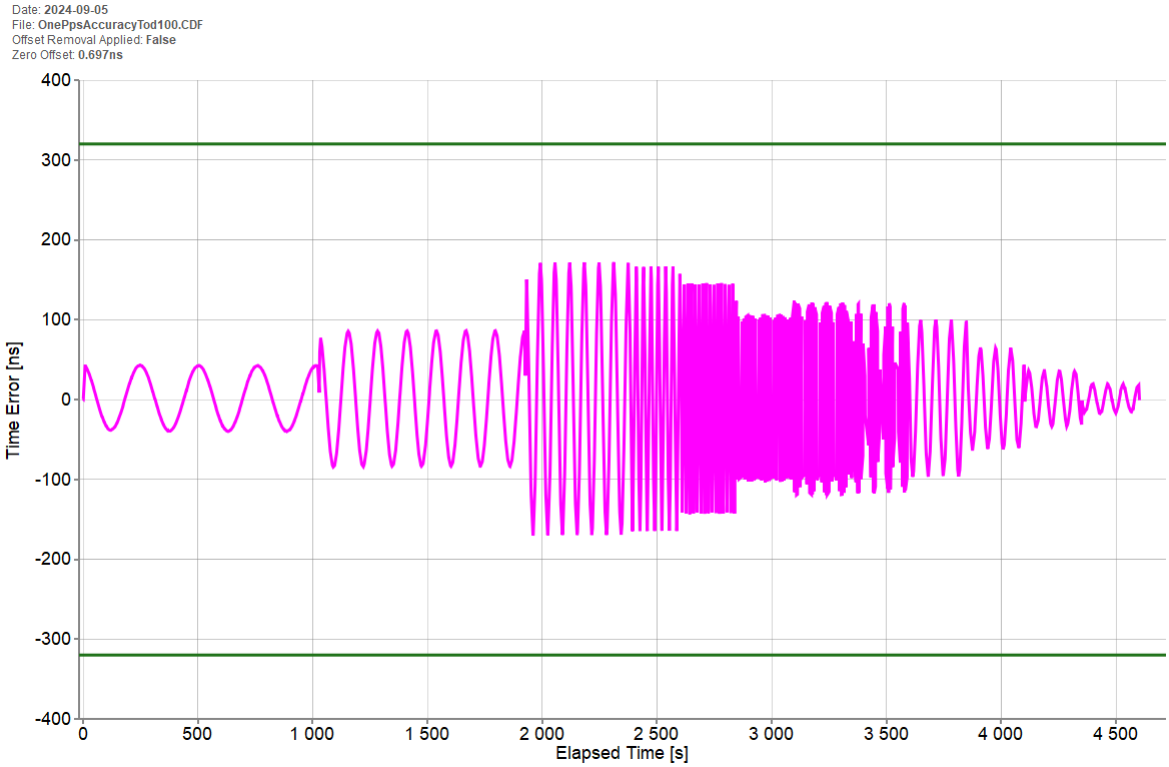
4.4.1 1PPS Measurements

Test Description	SyncE to 1PPS Noise Transfer
Report Date	24-09-06_12-21-02
Packet Rate (pkt/s)	16
Beginning of Test	9/5/2024 7:31:49 PM
Test Duration	01:16:42

All Mask Results	**Pass**
Mask ONEPPS	0.32µs
Mask ONEPPS Result	**Pass**
Mask SyncENoiseTransfer	G.8273.2 Class C T-BCs Noise Transfer
Mask SyncENoiseTransfer Result	**Pass**

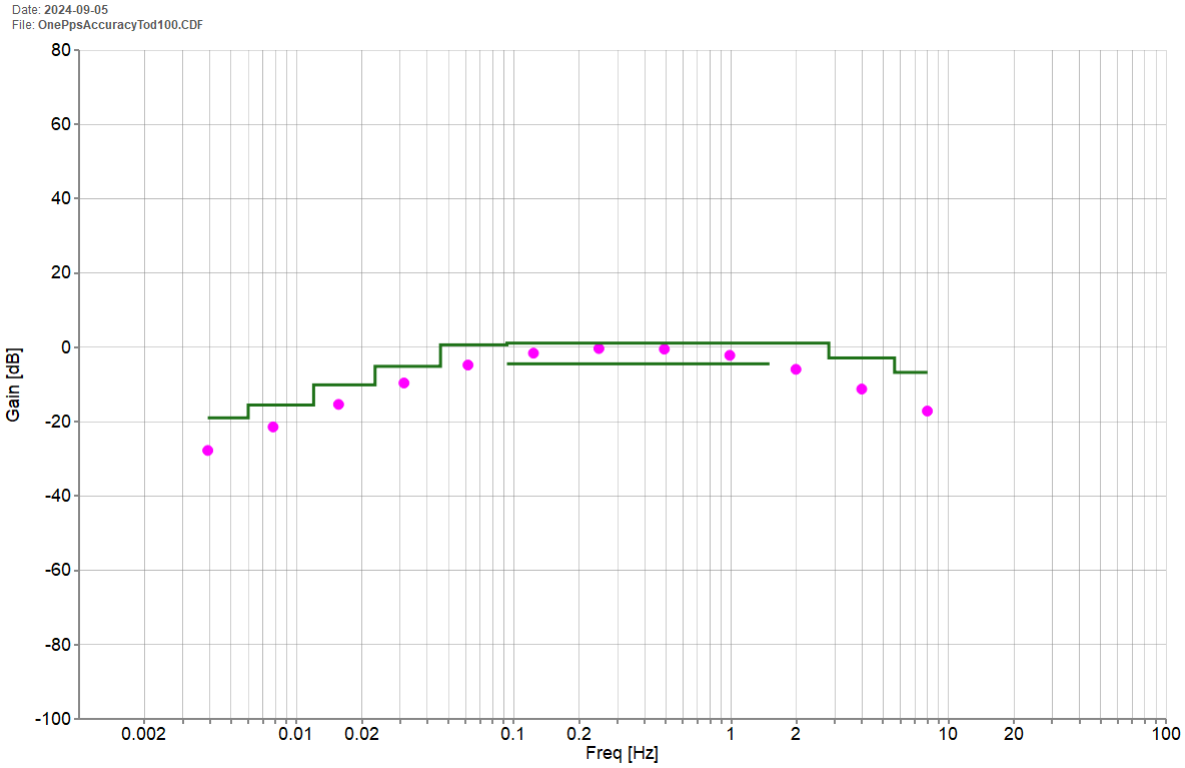
4.4.1.1 ONEPPS Analysis

Offset Removal Applied	Off
Zero Offset	0.697ns



Mean [ns]	0.968
Min [ns]	-170.053
Max [ns]	171.947
Max-Min [ns]	342

4.4.1.2 SyncENoiseTransfer Analysis



Point #	Freq (Hz)	Ampl (ns)	Duration (s)	Pk-Pk Output (ns)	Gain (dB)	Upper Pk-Pk Limit (ns)	Lower Pk-Pk Limit (ns)
1	0.00391	2000	1023.02	81.87	-27.76	**225**	-
2	0.00781	2000	896.29	169.71	-21.43	**340**	-
3	0.01563	2000	447.86	341.09	-15.36	**630**	-
4	0.03125	1000	224.00	331.09	-9.60	**565**	-
5	0.06156	500	243.66	288.80	-4.77	**545**	-
6	0.12313	250	251.77	208.74	-1.57	**285**	**150**
7	0.24625	250	251.78	240.79	-0.33	**285**	**150**
8	0.4925	250	249.75	236.52	-0.48	**285**	**150**
9	0.985	250	249.75	194.97	-2.16	**285**	**150**
10	1.985	250	249.87	126.40	-5.92	**285**	-
11	3.985	250	249.94	68.63	-11.23	**285**	-
12	7.985	250	249.97	34.72	-17.15	**285**	-

4.5 G.8273.2: PTP to PTP Noise Transfer

According to ITU-T G.8273.3 Section 7.3, the output PTP signal and 1 PPS signal must correspond to the input physical layer frequency input signal on which a band-pass filter whose lower corner frequency is between 0.05Hz and 0.1Hz and whose upper corner frequency is between 1Hz and 10Hz has been applied. This test checks whether T-BC under evaluation meets this bandpass filter requirement by adding sinusoidal noise on the SyncE (physical layer) input and measuring the output PTP noise amplitude.

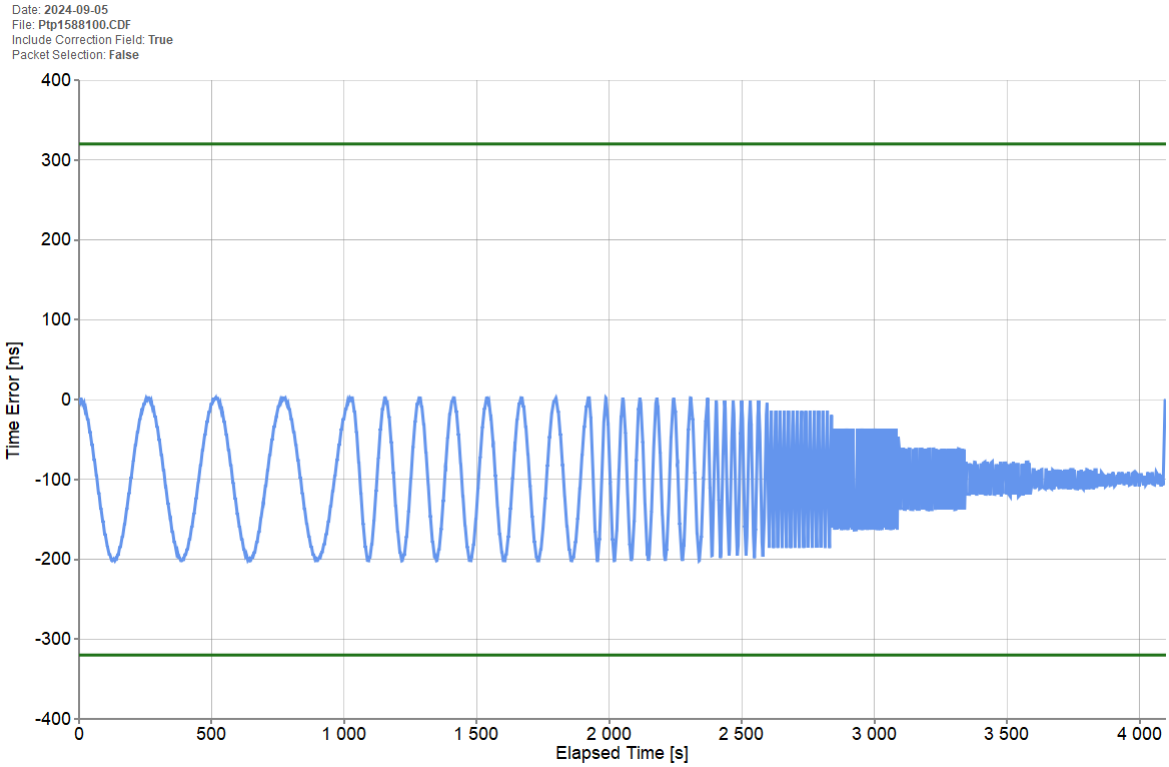
In this section, the standalone configuration (ts2phc, ptp4l, synced) with physical later assistance (SyncE) is tested for conformance to the Class C standard.

4.5.1 PTP Measurements

Test Description	PTP to PTP Noise Transfer
Report Date	24-09-06_12-21-02
Packet Rate (pkt/s)	16
Beginning of Test	9/5/2024 8:56:39 PM
Test Duration	04:28:13

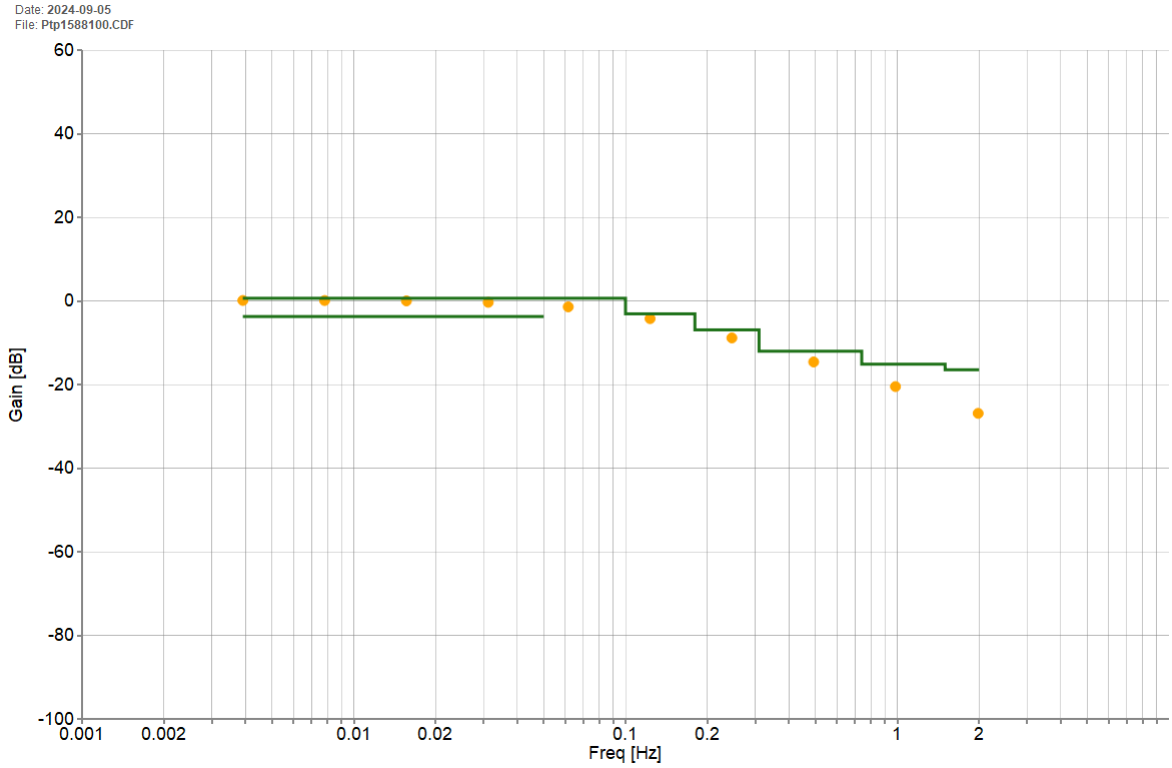
All Mask Results	**Pass**
Mask TIMEERROR	0.32µs
Mask TIMEERROR Result	**Pass**
Mask PTPNoiseTransfer	G.8273.2 Class C T-BCs Noise Transfer
Mask PTPNoiseTransfer Result	**Pass**

4.5.1.1 TIMEERROR Analysis



Pk-Pk [ns]	204.25
Mean [ns]	-99.478
Min [ns]	-202.075
Max [ns]	2.175

4.5.1.2 PTPNoiseTransfer Analysis



Point #	Freq (Hz)	Ampl (ns)	Duration (s)	Pk-Pk Output (ns)	Gain (dB)	Upper Pk-Pk Limit (ns)	Lower Pk-Pk Limit (ns)
1	0.00390625	200	1024.00	202.34	0.10	**215**	**130**
2	0.0078125	200	896.00	202.00	0.09	**215**	**130**
3	0.015625	200	448.00	200.01	0.00	**215**	**130**
4	0.03125	200	224.00	192.20	-0.35	**215**	**130**
5	0.0615625	200	243.65	169.64	-1.43	**215**	-
6	0.123125	200	251.78	122.66	-4.25	**140**	-
7	0.24625	200	251.78	72.10	-8.86	**90**	-
8	0.4925	200	249.75	37.22	-14.61	**50**	-
9	0.985	200	249.75	18.88	-20.50	**35**	-
10	1.985	200	249.87	9.03	-26.91	**30**	-

4.6 G.8273.2: PTP to 1PPS Noise Transfer

According to ITU-T G.8273.3 Section 7.3.1, the output 1PPS signal and 1 PPS signal must correspond to the input physical layer frequency input signal on which a band-pass filter whose lower corner frequency is between 0.05Hz and 0.1Hz and whose upper corner frequency is between 1Hz and 10Hz has been applied. This test checks whether T-BC under evaluation meets this bandpass filter requirement by adding sinusoidal noise on the SyncE (physical layer) input and measuring the output 1PPS noise amplitude.

In this section, the standalone configuration (ts2phc, ptp4l, synced) with physical later assistance (SyncE) is tested for conformance to the Class C standard.

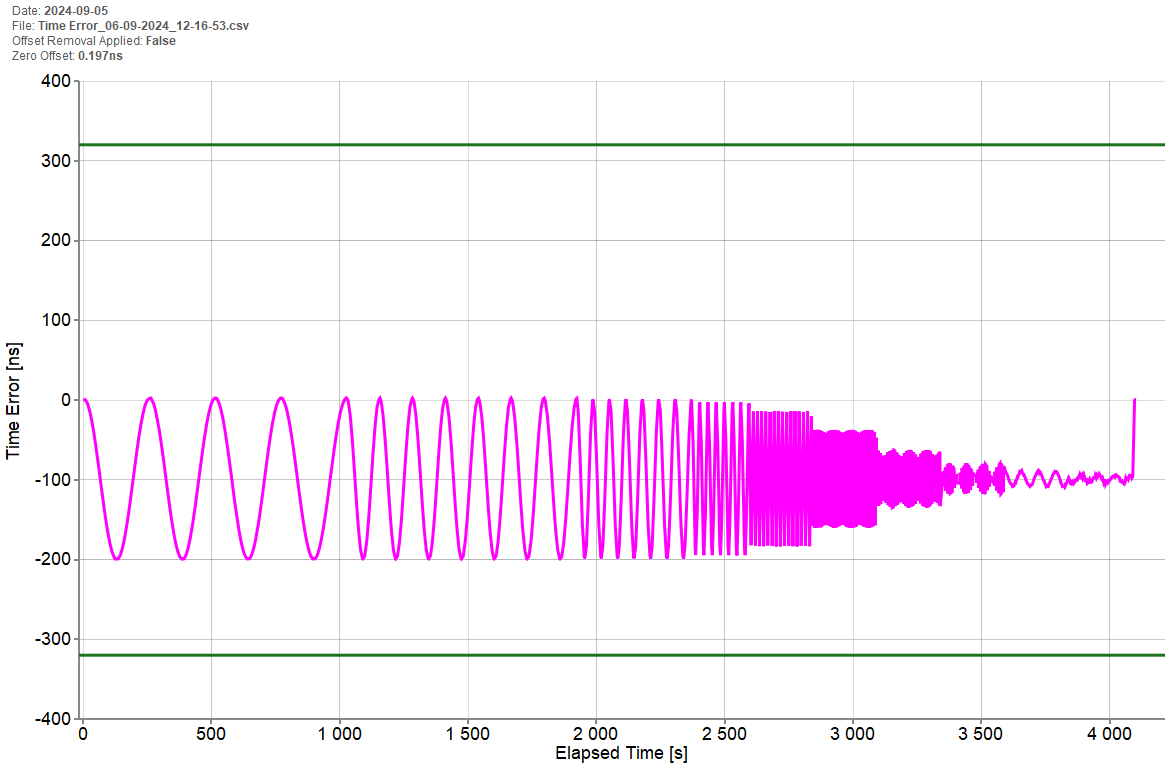
4.6.1 1PPS Measurements

Test Description	PTP to 1PPS Noise Transfer
Report Date	24-09-06_14-57-42
Packet Rate (pkt/s)	16
Beginning of Test	9/5/2024 8:56:39 PM
Test Duration	01:08:20

All Mask Results	**Pass**
Mask ONEPPS	0.32µs
Mask ONEPPS Result	**Pass**
Mask PTPNoiseTransfer	G.8273.2 Class C T-BCs Noise Transfer
Mask PTPNoiseTransfer Result	**Pass**

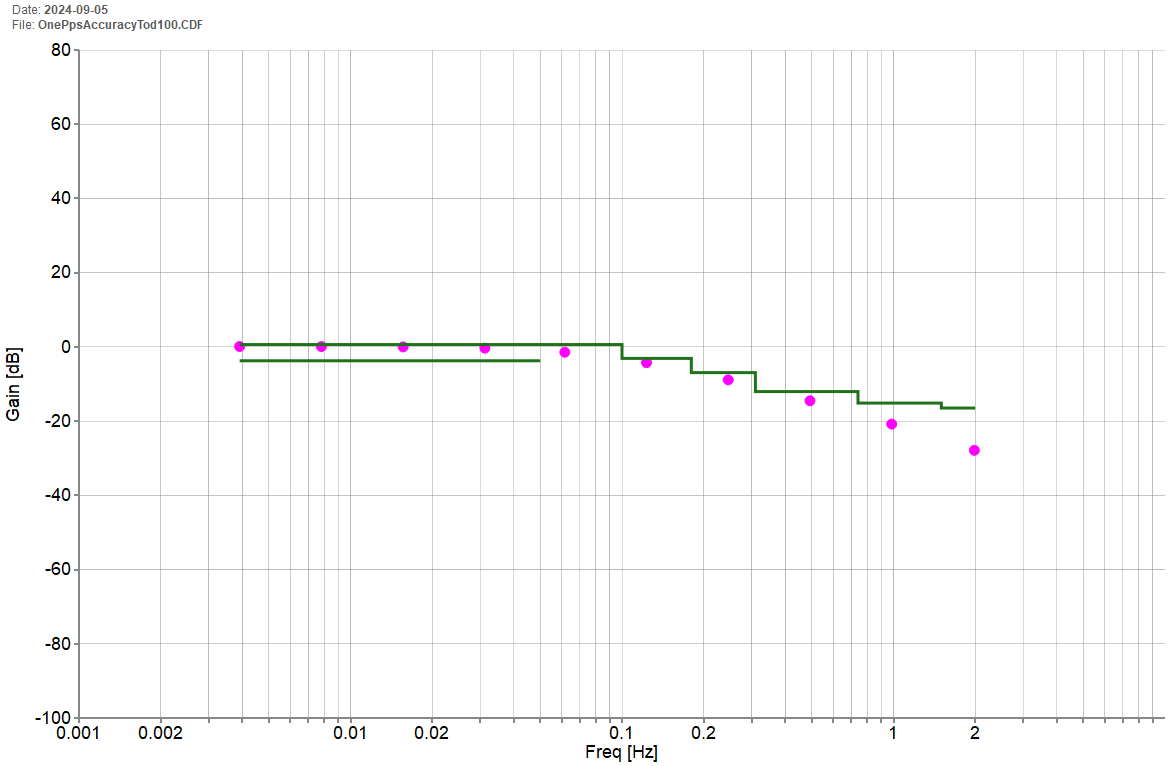
4.6.1.1 ONEPPS Analysis

Offset Removal Applied	Off
Zero Offset	0.197ns



Mean [ns]	-98.549
Min [ns]	-199.553
Max [ns]	2.697
Max-Min [ns]	202.25

4.6.1.2 PTPNoiseTransfer Analysis



Point #	Freq (Hz)	Ampl (ns)	Duration (s)	Pk-Pk Output (ns)	Gain (dB)	Upper Pk-Pk Limit (ns)	Lower Pk-Pk Limit (ns)
1	0.00390625	200	1024.00	202.40	0.10	**215**	**130**
2	0.0078125	200	896.00	202.04	0.09	**215**	**130**
3	0.015625	200	448.00	199.88	-0.01	**215**	**130**
4	0.03125	200	224.00	192.31	-0.34	**215**	**130**
5	0.0615625	200	243.65	169.52	-1.44	**215**	-
6	0.123125	200	251.78	122.56	-4.25	**140**	-
7	0.24625	200	251.78	71.92	-8.88	**90**	-
8	0.4925	200	249.75	37.54	-14.53	**50**	-
9	0.985	200	249.75	18.24	-20.80	**35**	-
10	1.985	200	249.87	8.08	-27.87	**30**	-

4.7 G.8273.2: SyncE Transient

This test emulates a reference switch between physical layer (SyncE) frequency references. A reference switch can generate a large transient on the physical layer and a T-BC must reject this transient. A combination of frequency changes and ESMC messages are used to input the 'worst case' transient based on the SyncE transient pattern shown in ITU-T G.8273. The output PTP and 1PPS of the T-BC must remain within the mask defined by ITU-G.8273.2 Section 7.4.1/Annex C.

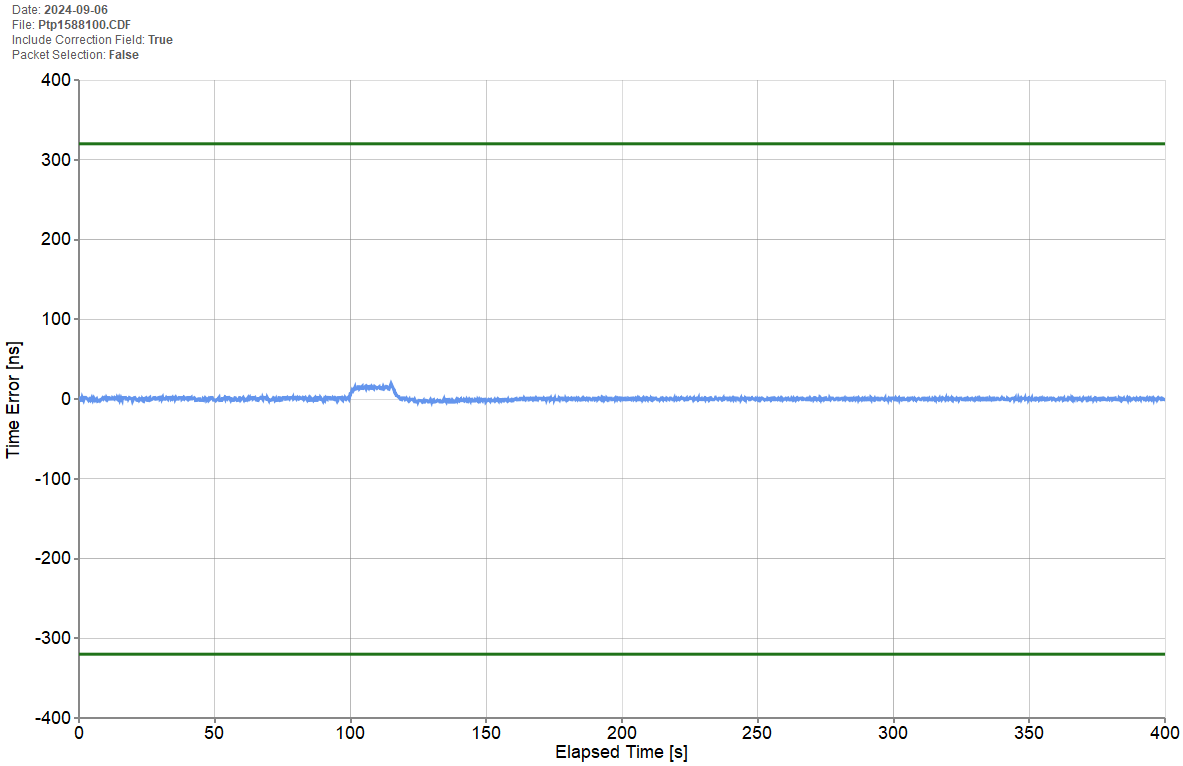
In this section, the standalone configuration (ts2phc, ptp4l, synced) with physical later assistance (SyncE) is tested for conformance to the Class C standard using the ITU-T G.8262 (EEC1) SyncE Transient.

4.7.1 PTP Measurements

Test Description	synce_transient_bc
Report Date	24-09-06_14-57-42
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 12:14:57 PM
Test Duration	00:08:00

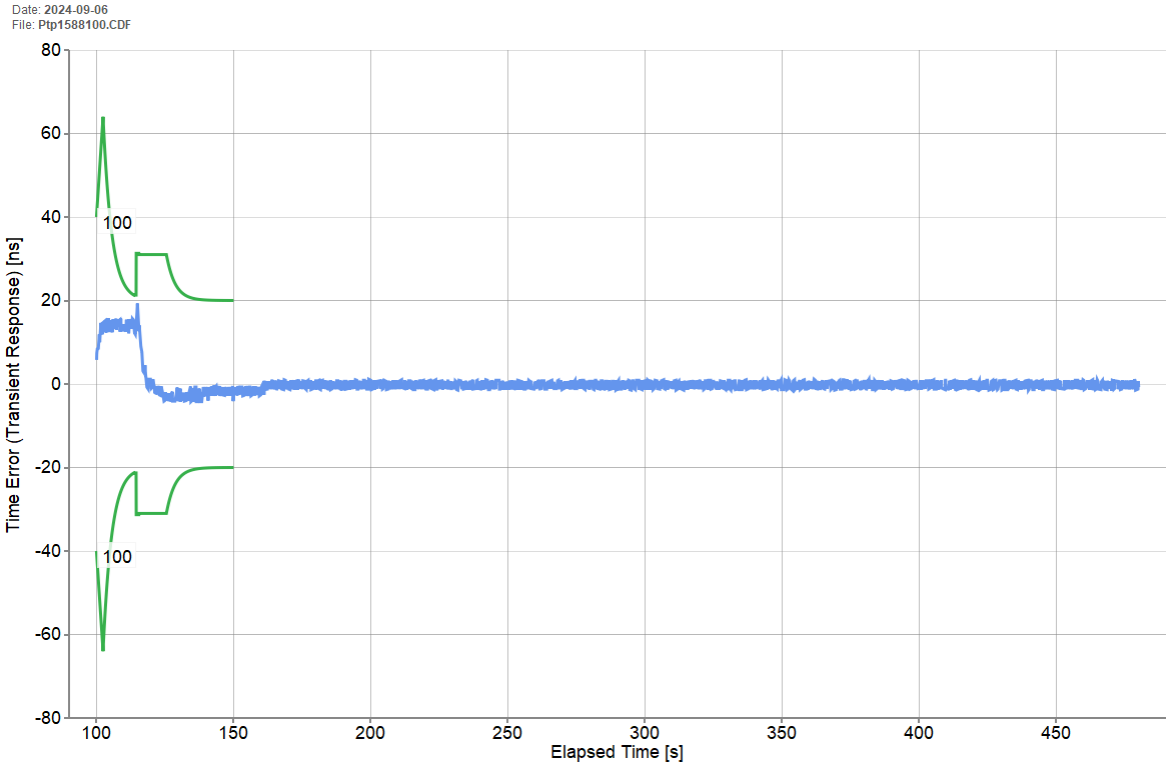
All Mask Results	**Pass**
Mask TIMEERROR	0.32µs
Mask TIMEERROR Result	**Pass**
Mask TransientResponse	G.8273.2 Class C Phase Error
Mask TransientResponse Result	**Pass**

4.7.1.1 TIMEERROR Analysis



Pk-Pk [ns]	23.5
Mean [ns]	0.498
Min [ns]	-3.956
Max [ns]	19.544

4.7.1.2 TransientResponse Analysis



Mean [ns]	0.188
Min [ns]	-4.23
Max [ns]	19.27
Max-Min [ns]	23.5

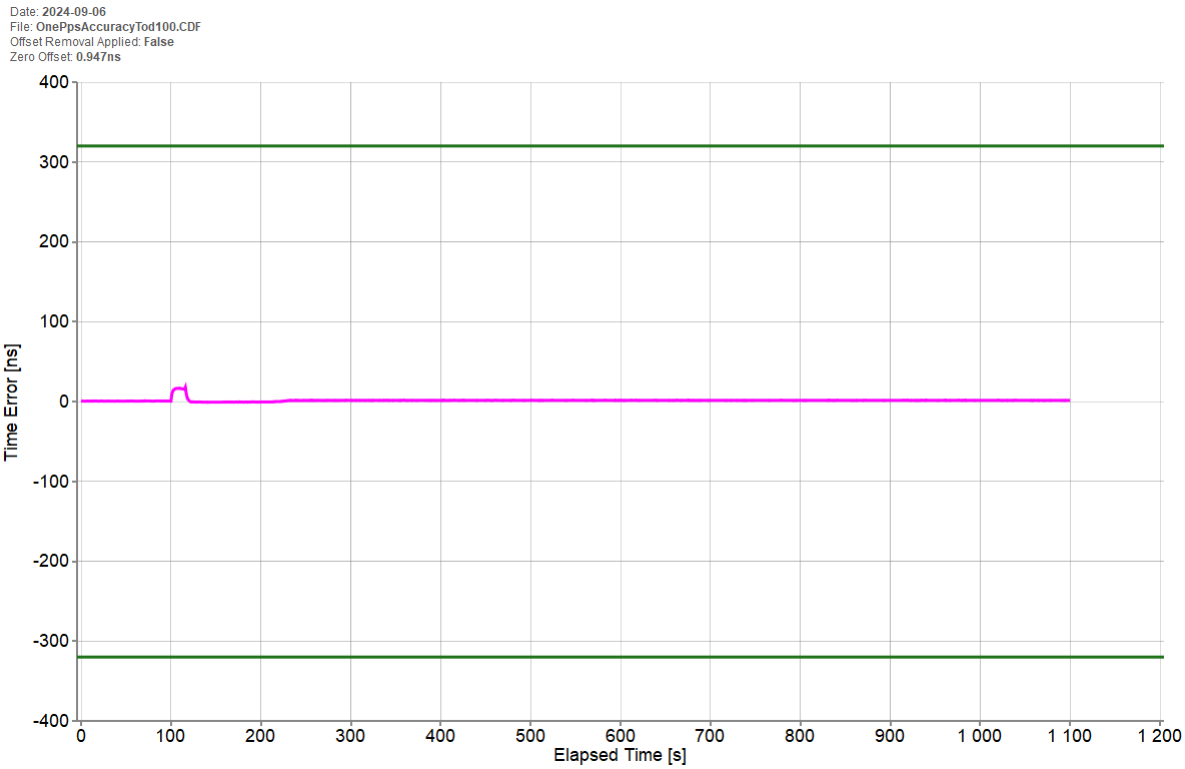
4.7.2 1PPS Measurements

Test Description	SyncE Transient
Report Date	24-09-06_14-57-42
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 12:41:37 PM
Test Duration	00:18:20

All Mask Results	**Pass**
Mask ONEPPS	0.32µs
Mask ONEPPS Result	**Pass**
Mask TransientResponse	G.8273.2 Class C Phase Error
Mask TransientResponse Result	**Pass**

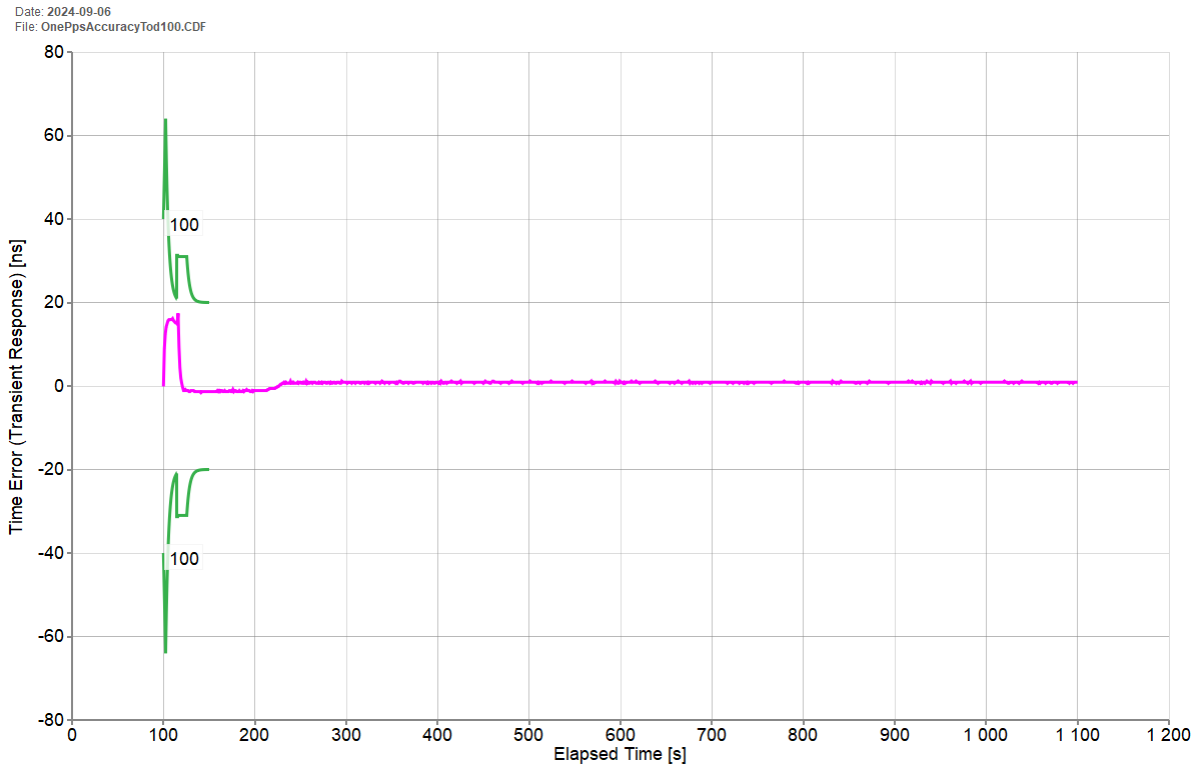
4.7.2.1 ONEPPS Analysis

Offset Removal Applied	Off
Zero Offset	0.947ns



Mean [ns]	1.359
Min [ns]	-1.053
Max [ns]	17.947
Max-Min [ns]	19

4.7.2.2 TransientResponse Analysis



Mean [ns]	0.899
Min [ns]	-1.595
Max [ns]	17.405
Max-Min [ns]	19

4.8 G.8273.2: G.8271.1 Reference Point C PDV

This test checks whether the equipment clock can maintain network limits at the output with maximum noise at the input. The noise tolerance of a clock indicates the minimum time error level at the input of the clock that should be accommodated while: not causing any alarms; not causing the clock to switch reference; not causing the clock to go into holdover.

The level of noise that a PTS device must tolerate on its PTP input is defined according to the network limit defined in ITU-T G.8271.1 clause 7.3.

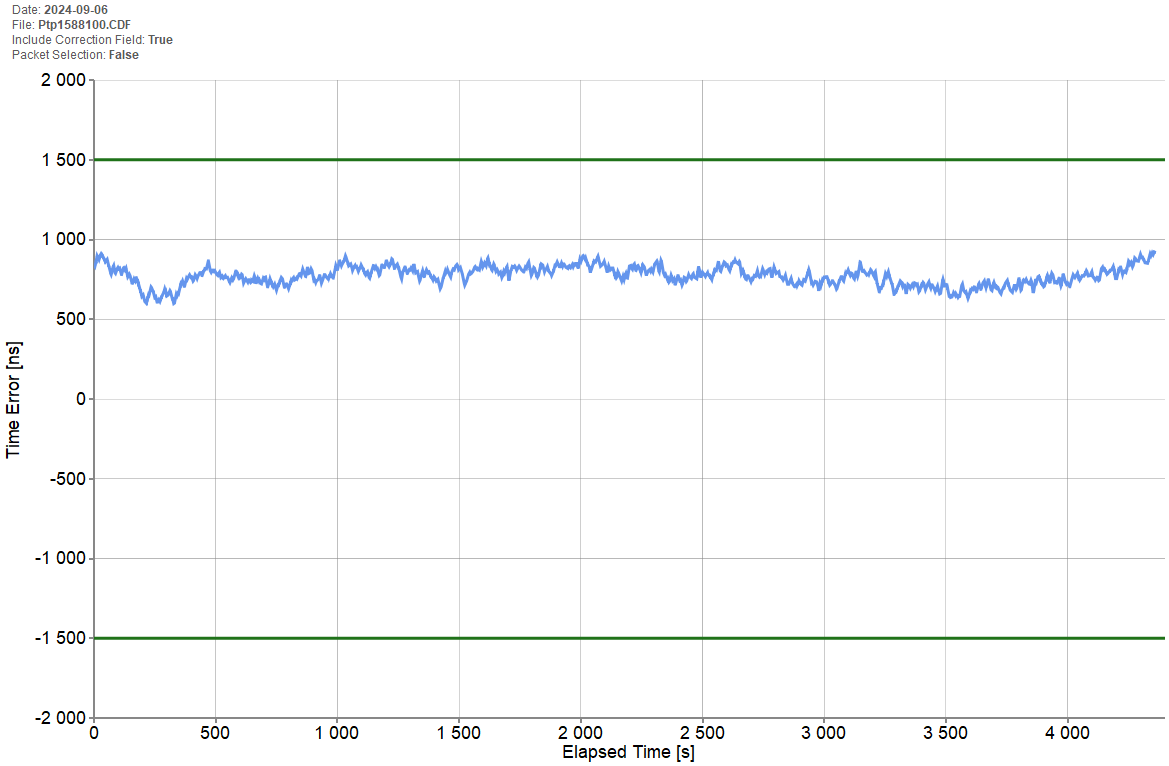
For this test, the G.8271.1 clause 7.3 PDV pattern is applied to the PTP input and the output 1PPS and PTP performance is observed. The standalone configuration (ts2phc, ptp4l, synced) with physical layer assistance (SyncE) is used during this test.

4.8.1 PTP Measurements

Test Description	G.8271.1 Reference Point C PDV
Report Date	24-09-06_14-57-42
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 1:25:21 PM
Test Duration	01:12:38

All Mask Results	**Pass**
Mask TIMEERROR	1500µs
Mask TIMEERROR Result	**Pass**

4.8.1.1 TIMEERROR Analysis



Pk-Pk [ns]	331.625
Mean [ns]	772.311
Min [ns]	598.165
Max [ns]	929.79

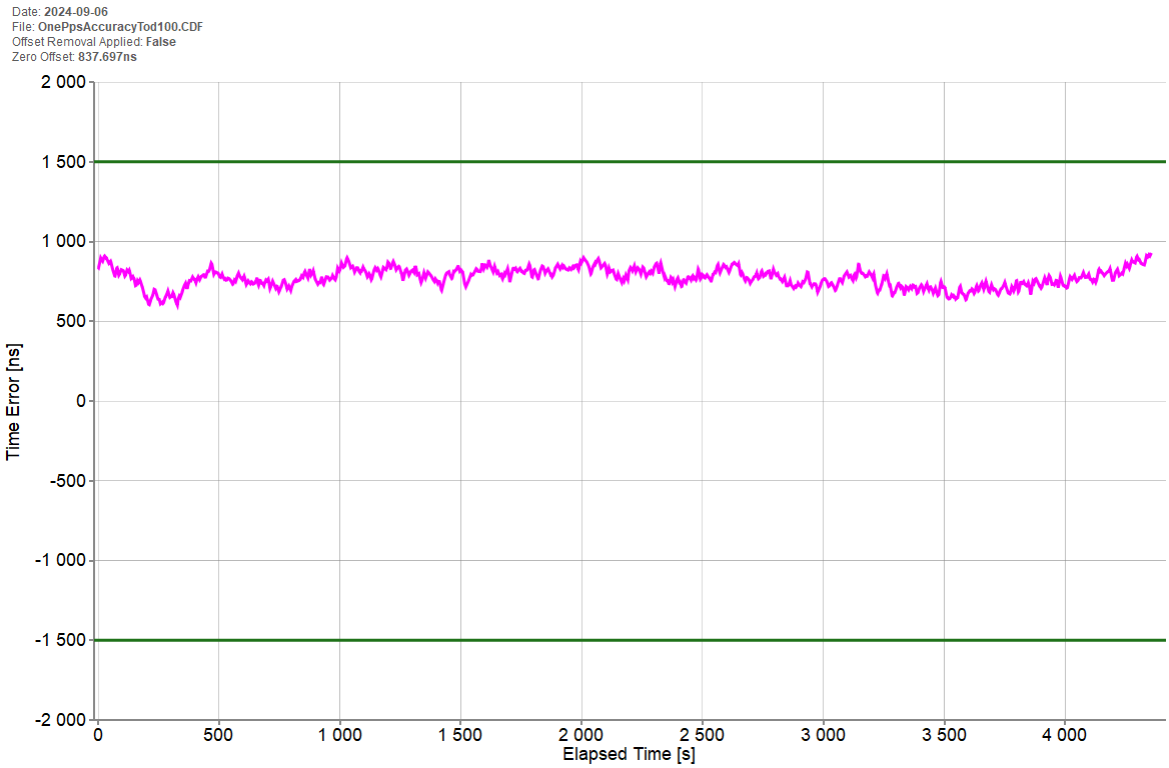
4.8.2 1PPS Measurements

Test Description	G.8271.1 Reference Point C PDV
Report Date	24-09-06_14-57-42
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 1:25:21 PM
Test Duration	01:12:36

All Mask Results	**Pass**
Mask ONEPPS	1500µs
Mask ONEPPS Result	**Pass**

4.8.2.1 ONEPPS Analysis

Offset Removal Applied	Off
Zero Offset	837.697ns



Mean [ns]	773.269
Min [ns]	600.697
Max [ns]	927.947
Max-Min [ns]	327.25

5. External Servo Tests (pcm4l, ptp4l, synced)

5.1 G.8273.2: Noise Generation

The noise generation of a T-BC represents the amount of noise produced at the output of the T-BC when there is an ideal input reference packet timing signal. The noise generation is measured on both the PTP and 1PPS outputs of the DUT.

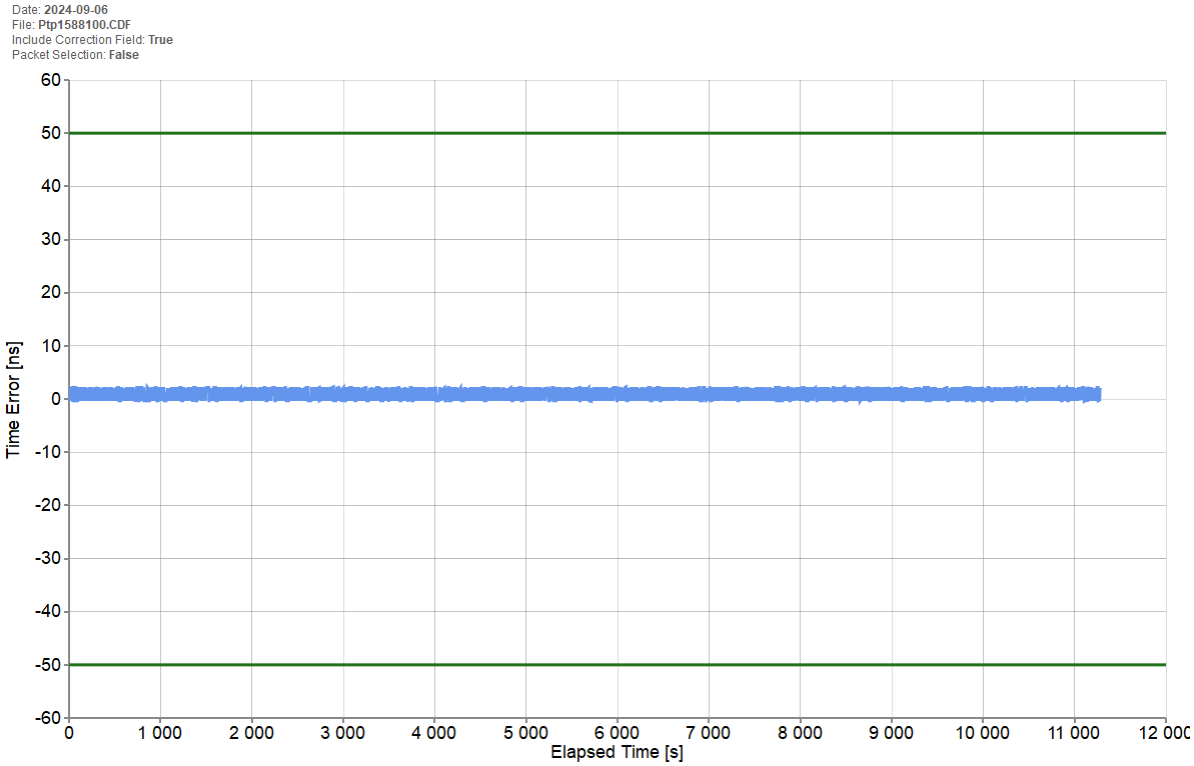
In this section, the external servo configuration (pcm4l, ptp4l, synced) is tested for conformance to ITU-T G.8273.2 Section 7.1 Class D. Physical layer assistance (SyncE) is used during this test.

5.1.1 PTP Measurements

Test Description	Noise Generation
Report Date	24-09-06_14-57-42
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 3:05:22 PM
Test Duration	03:07:59
Time to Phase Lock (s)	10

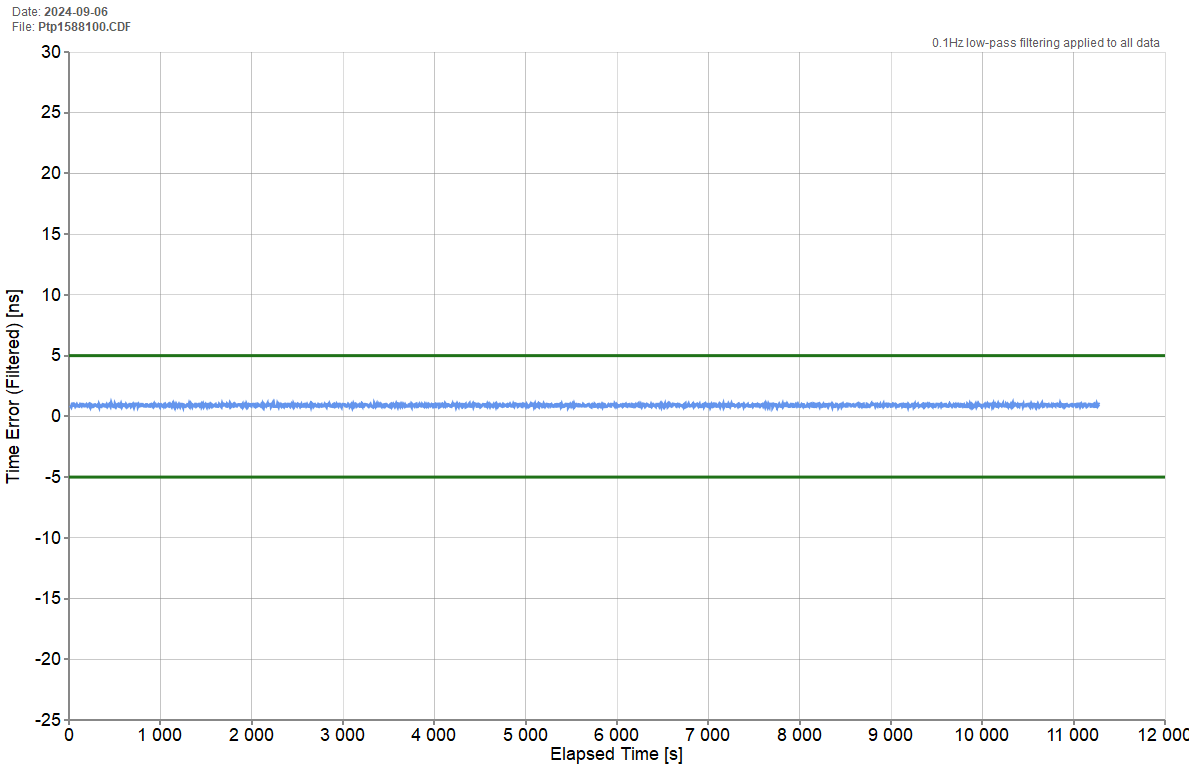
All Mask Results	**Pass**
Mask TIMEERROR	0.05µs
Mask TIMEERROR Result	**Pass**
Mask FILTEREDTIMEERROR	0.005µs
Mask FILTEREDTIMEERROR Result	**Pass**
Mask CTE	0.01µs
Mask CTE Result	**Pass**
Mask DTE	0.01µs
Mask DTE Result	**Pass**
Mask DTEHF	0.07µs
Mask DTEHF Result	**Pass**
Mask DTEMTIE	G.8273.2 T-BC Class C Dynamic TE LF Const. Temp.
Mask DTEMTIE Result	**Pass**
Mask DTETDEV	G.8273.2 T-BC Class C Dynamic TE LF Const. Temp.
Mask DTETDEV Result	**Pass**

5.1.1.1 TIMEERROR Analysis



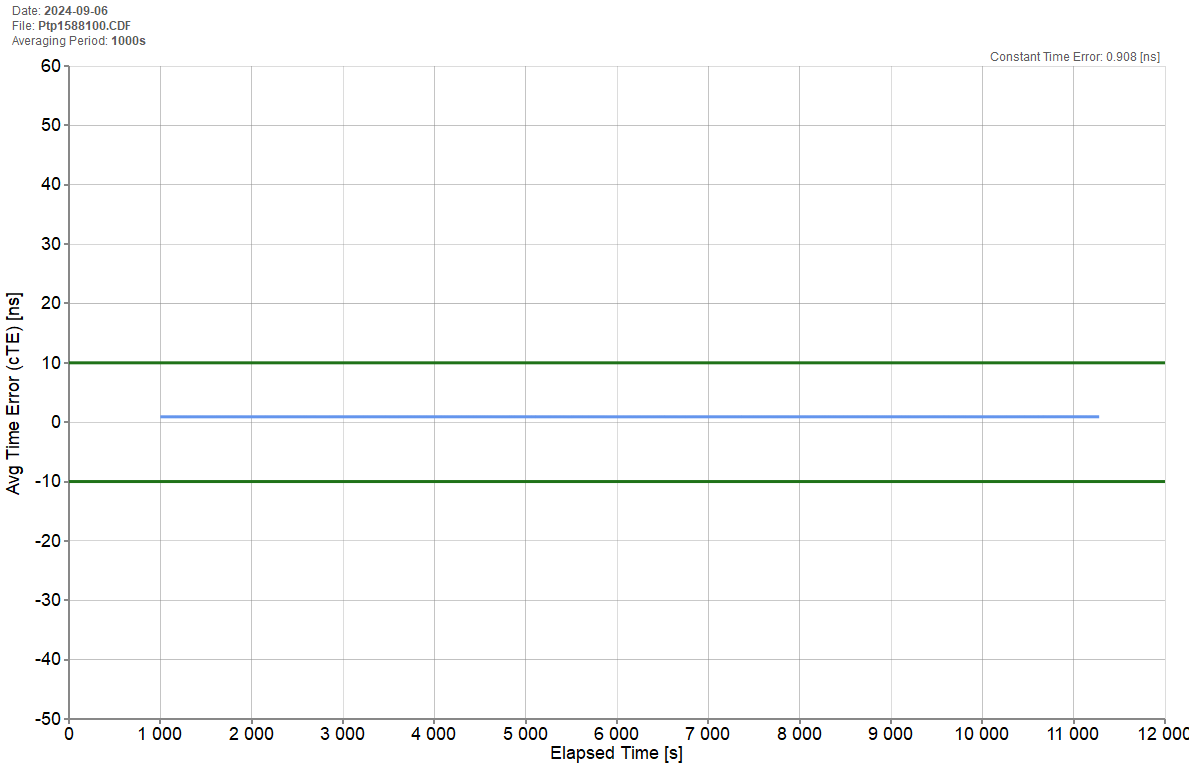
Pk-Pk [ns]	2.75
Mean [ns]	0.908
Min [ns]	-0.464
Max [ns]	2.286

5.1.1.2 FILTEREDTIMEERROR Analysis



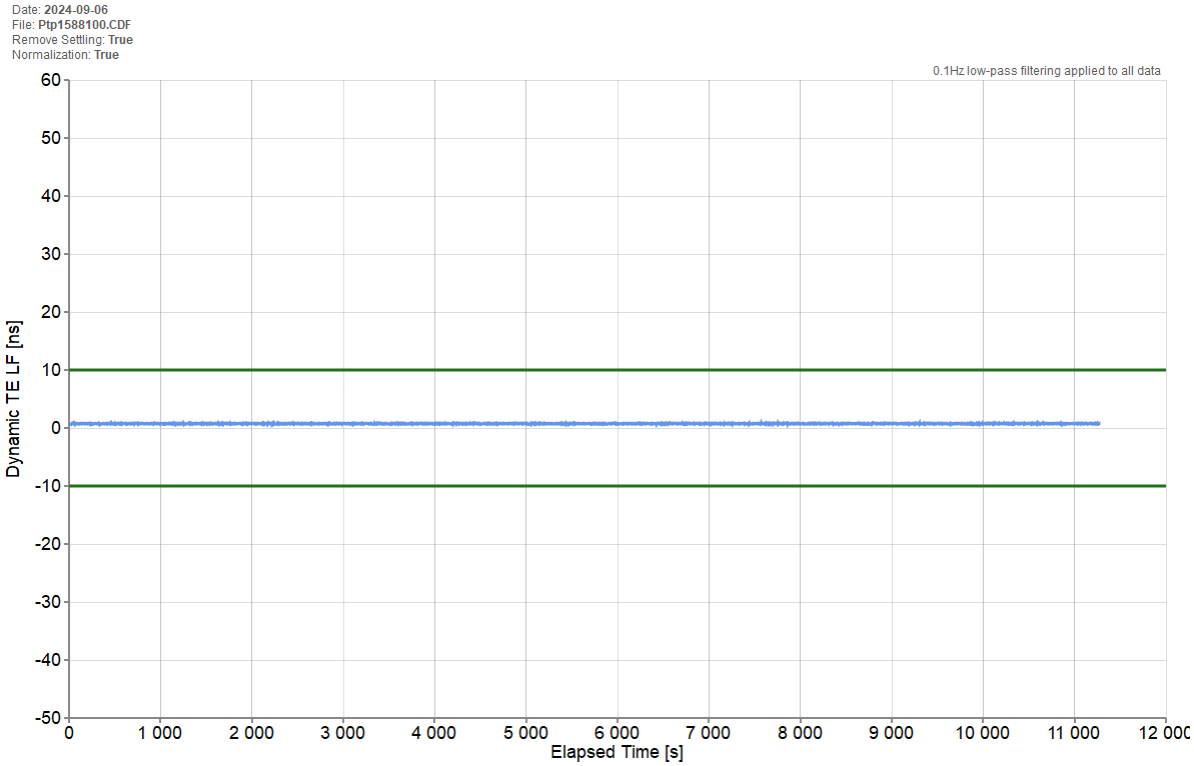
Mean [ns]	0.908
Min [ns]	0.725
Max [ns]	1.087
Max-Min [ns]	0.362

5.1.1.3 CTE Analysis



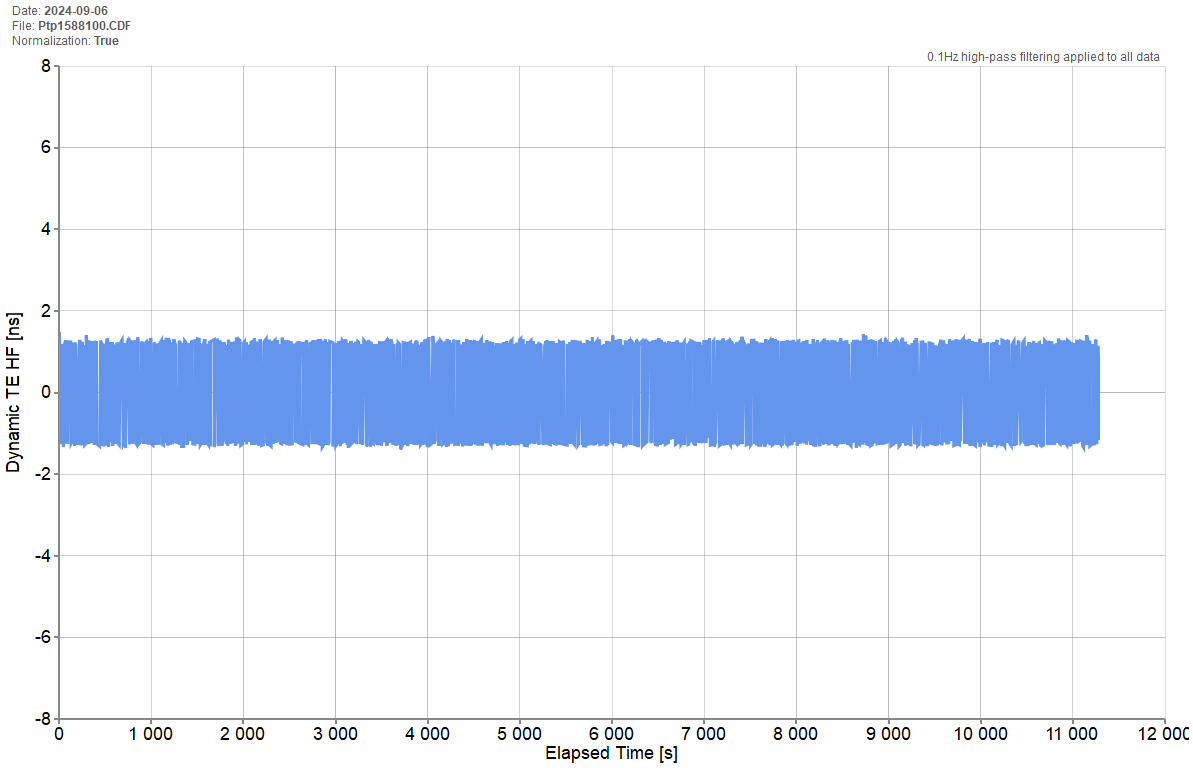
Averaging Time (s)	1000
Constant Time Error [ns]	0.908
Min [ns]	0.903
Max [ns]	0.912
Max-Min [ns]	0.01

5.1.1.4 DTE Analysis



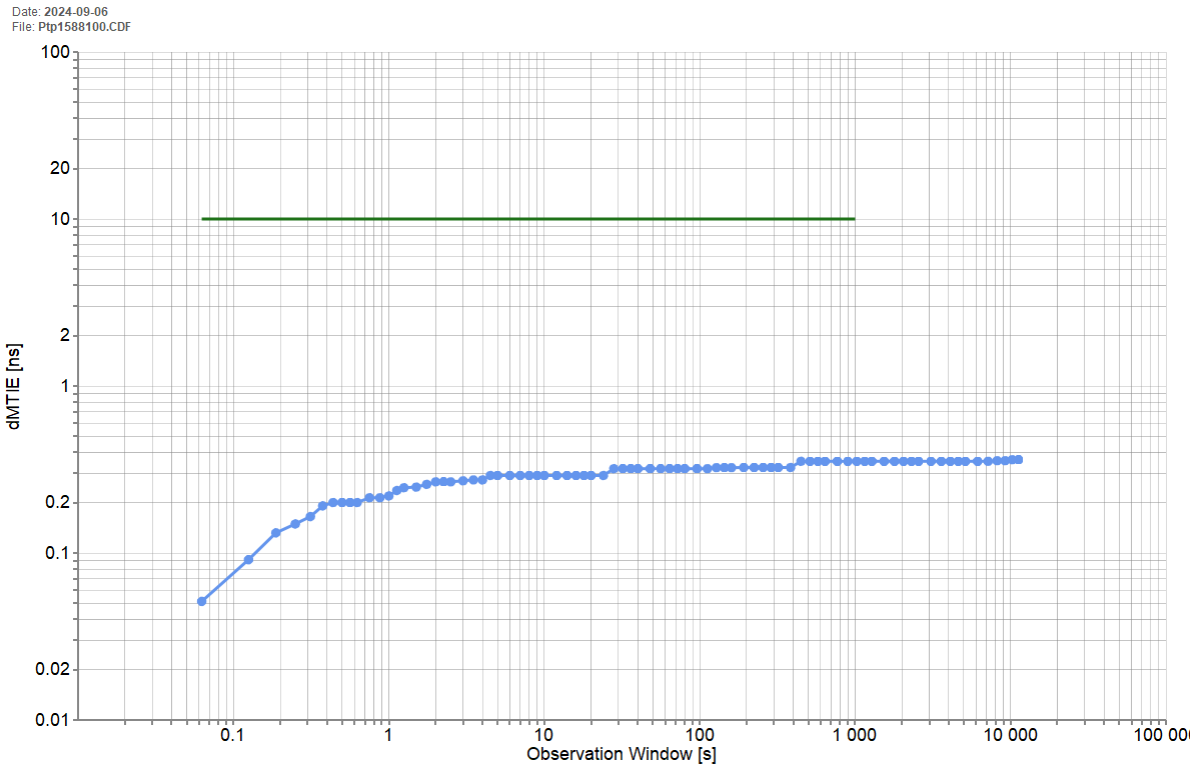
Mean [ns]	0.747
Min [ns]	0.564
Max [ns]	0.926
Max-Min [ns]	0.362

5.1.1.5 DTEHF Analysis



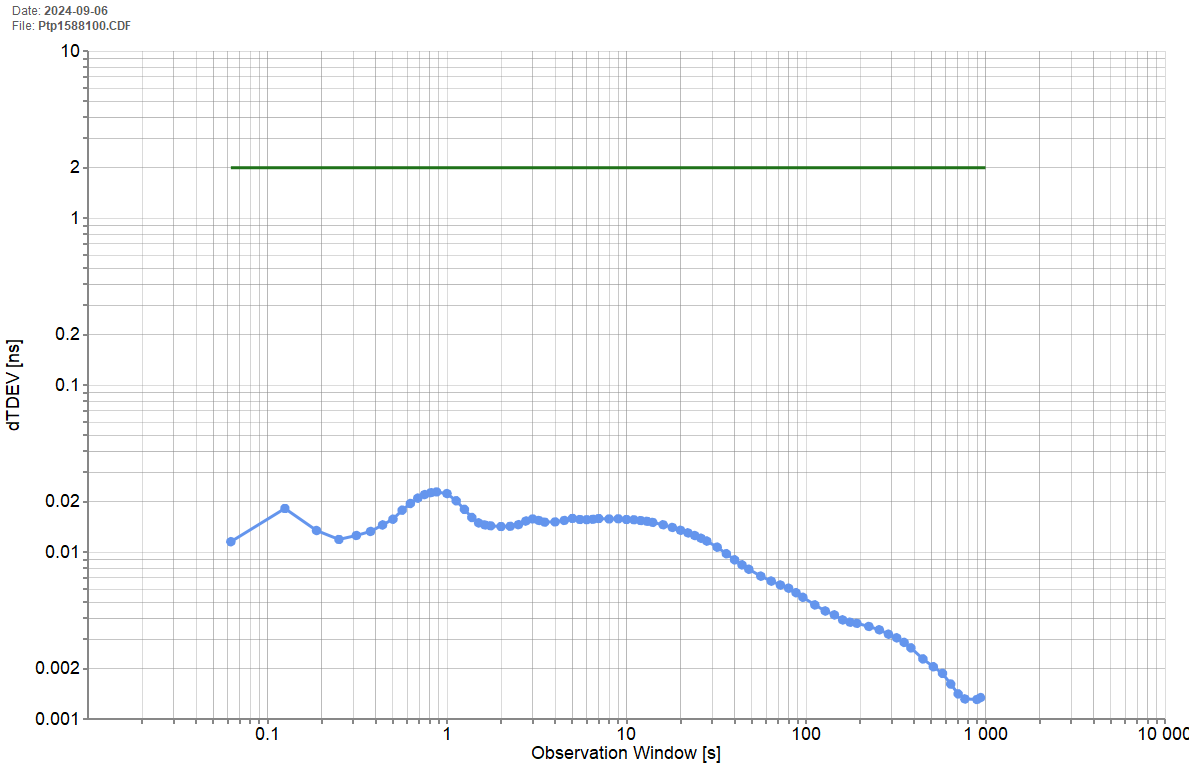
Pk-Pk [ns]	2.876
Mean [ns]	0
Min [ns]	-1.393
Max [ns]	1.483

5.1.1.6 DTEMTIE Analysis



Min [ns]	0.051
Max [ns]	0.362
Max-Min [ns]	0.31

5.1.1.7 DTETDEV Analysis



Min [ns]	0.001
Max [ns]	0.023
Max-Min [ns]	0.022

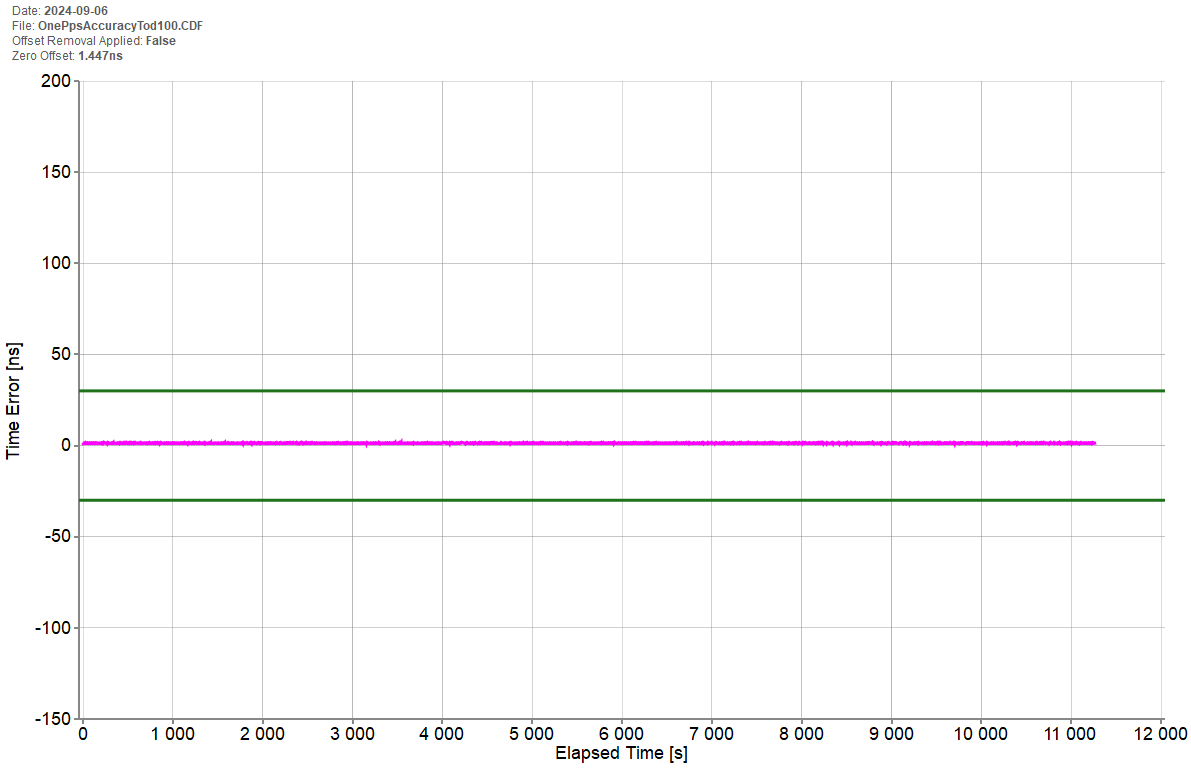
5.1.2 1PPS Measurements

Test Description	Noise Generation
Report Date	24-09-06_14-57-42
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 3:05:22 PM
Test Duration	03:07:58
Time to Phase Lock (s)	10

All Mask Results	**Pass**
Mask ONEPPS	0.03µs
Mask ONEPPS Result	**Pass**
Mask FILTEREDTIMEERROR	0.005µs
Mask FILTEREDTIMEERROR Result	**Pass**
Mask CTE	0.01µs
Mask CTE Result	**Pass**
Mask DTE	0.01µs
Mask DTE Result	**Pass**
Mask DTEHF	0.07µs
Mask DTEHF Result	**Pass**
Mask DTEMTIE	G.8273.2 T-BC Provisional Class D Dynamic TE LF Const. Temp.
Mask DTEMTIE Result	**Pass**
Mask DTETDEV	G.8273.2 T-BC Provisional Class D Dynamic TE LF Const. Temp.
Mask DTETDEV Result	**Pass**

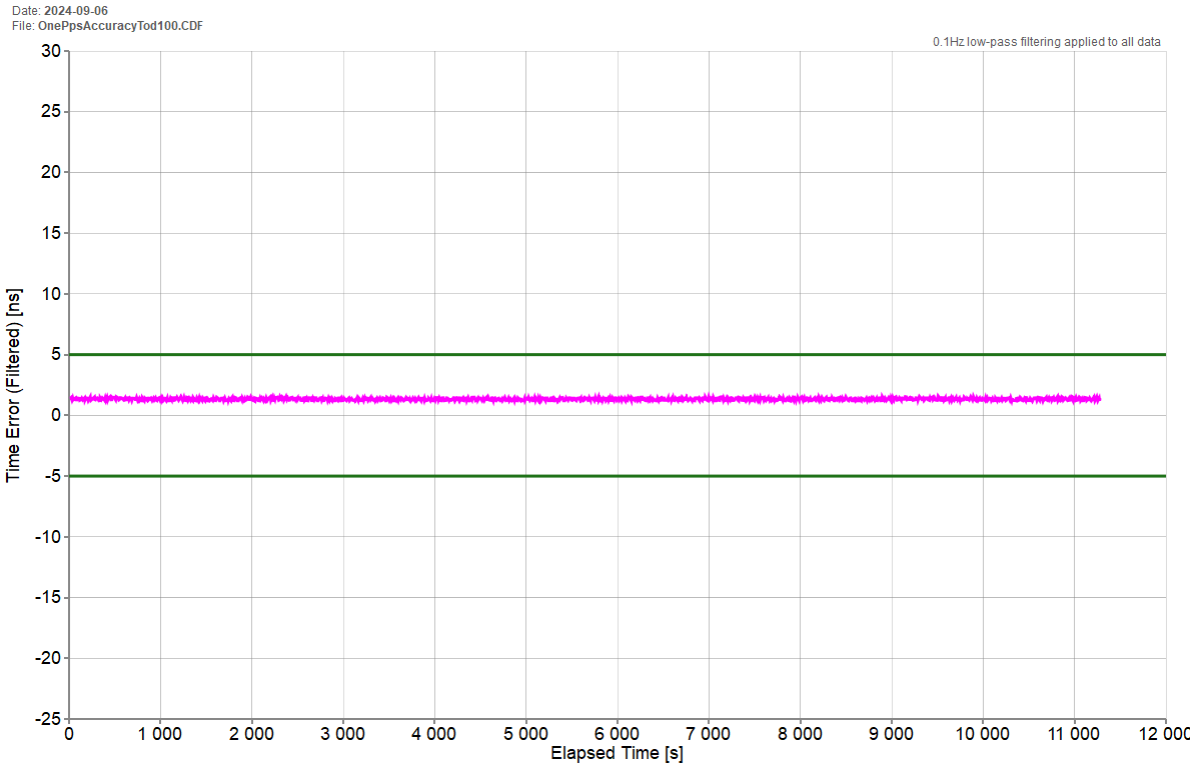
5.1.2.1 ONEPPS Analysis

Offset Removal Applied	Off
Zero Offset	1.447ns



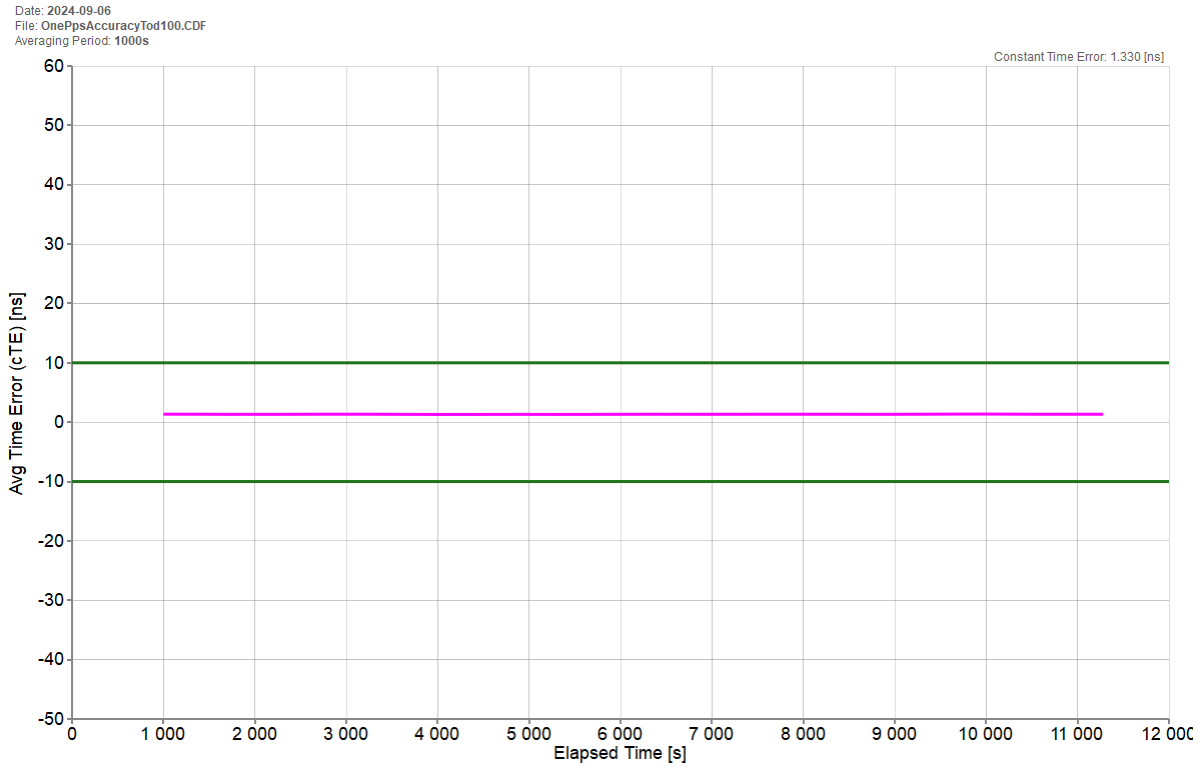
Mean [ns]	1.331
Min [ns]	1.197
Max [ns]	1.697
Max-Min [ns]	0.5

5.1.2.2 FILTEREDTIMEERROR Analysis



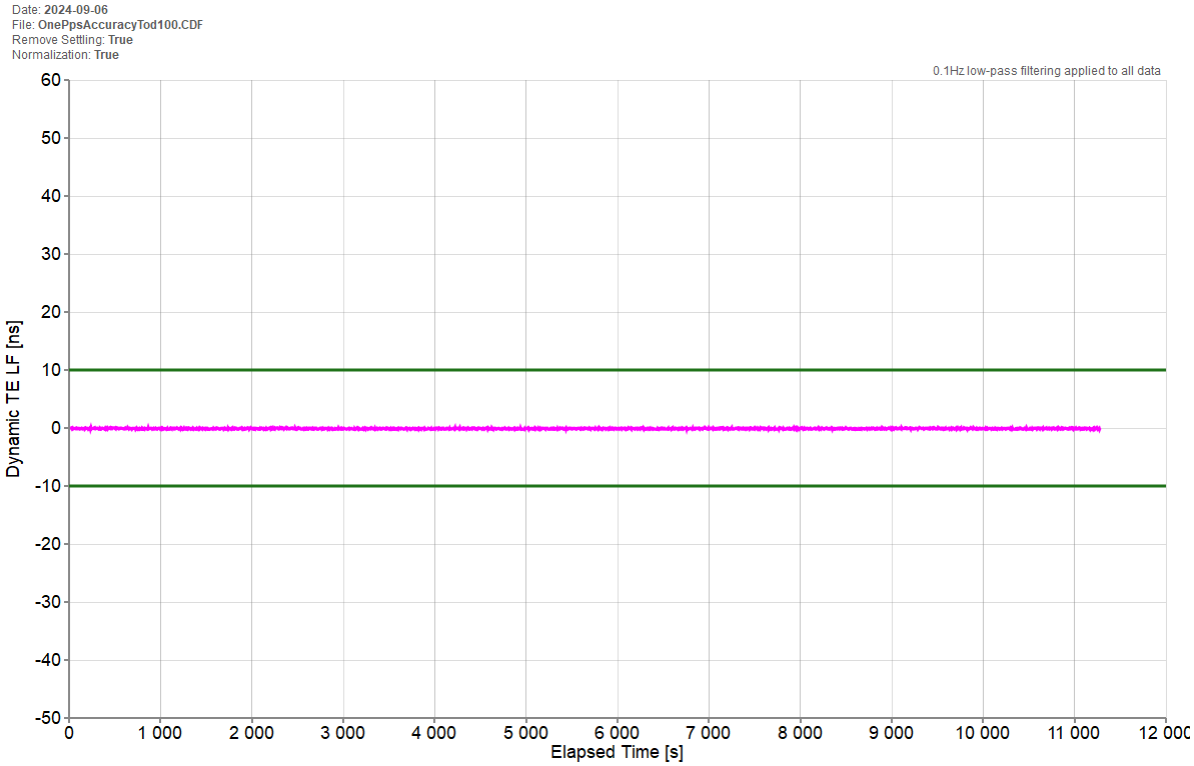
Mean [ns]	1.331
Min [ns]	1.197
Max [ns]	1.6
Max-Min [ns]	0.403

5.1.2.3 CTE Analysis



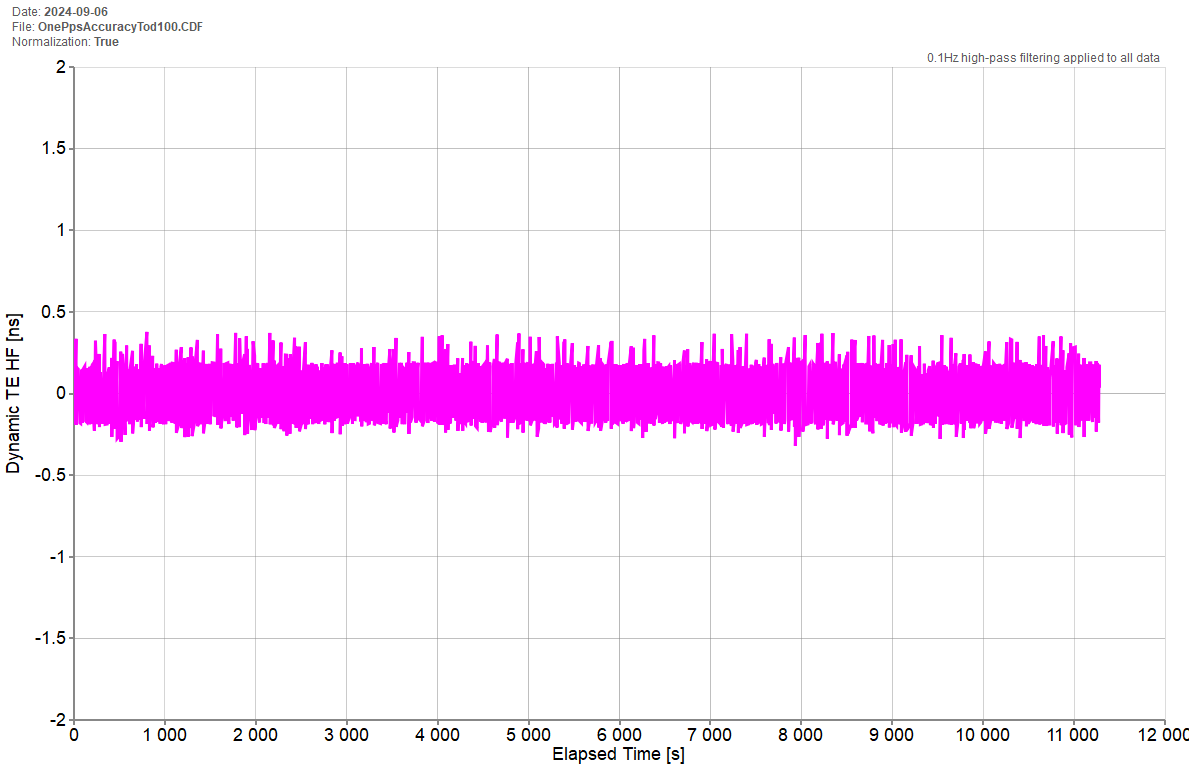
Averaging Time (s)	1000
Constant Time Error [ns]	1.33
Min [ns]	1.302
Max [ns]	1.367
Max-Min [ns]	0.065

5.1.2.4 DTE Analysis



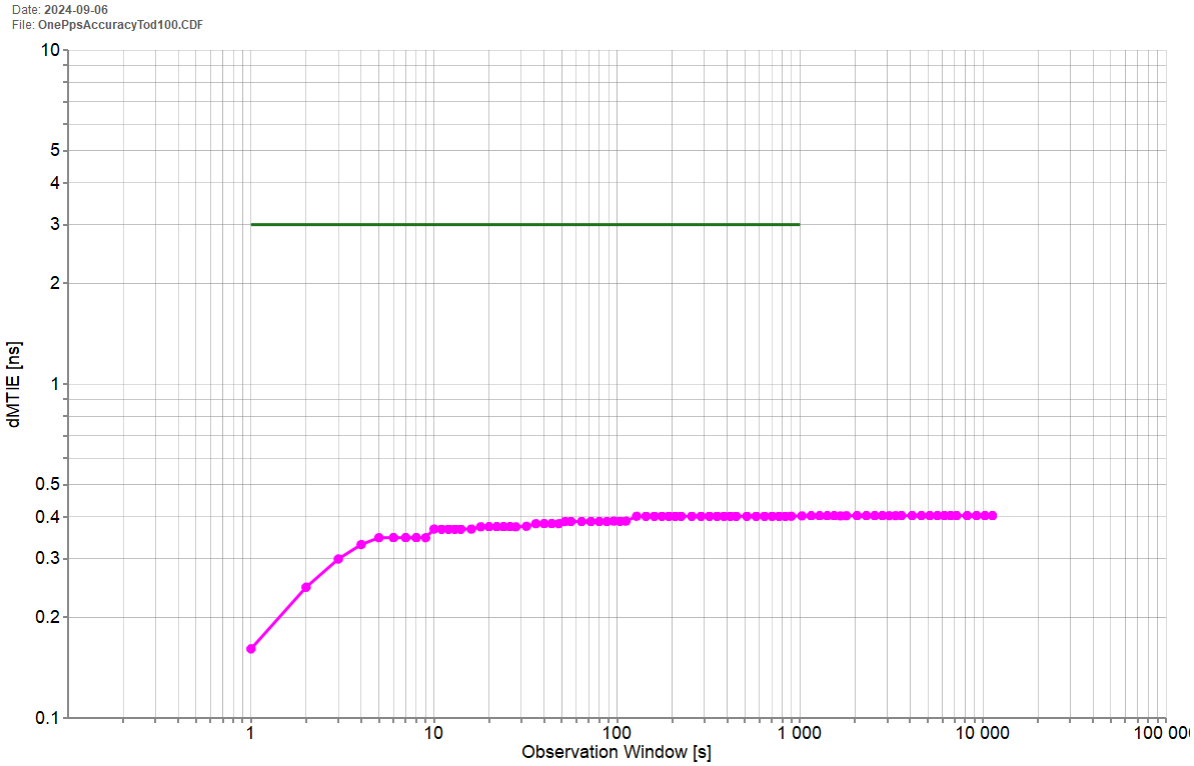
Mean [ns]	-0.116
Min [ns]	-0.25
Max [ns]	0.153
Max-Min [ns]	0.403

5.1.2.5 DTEHF Analysis



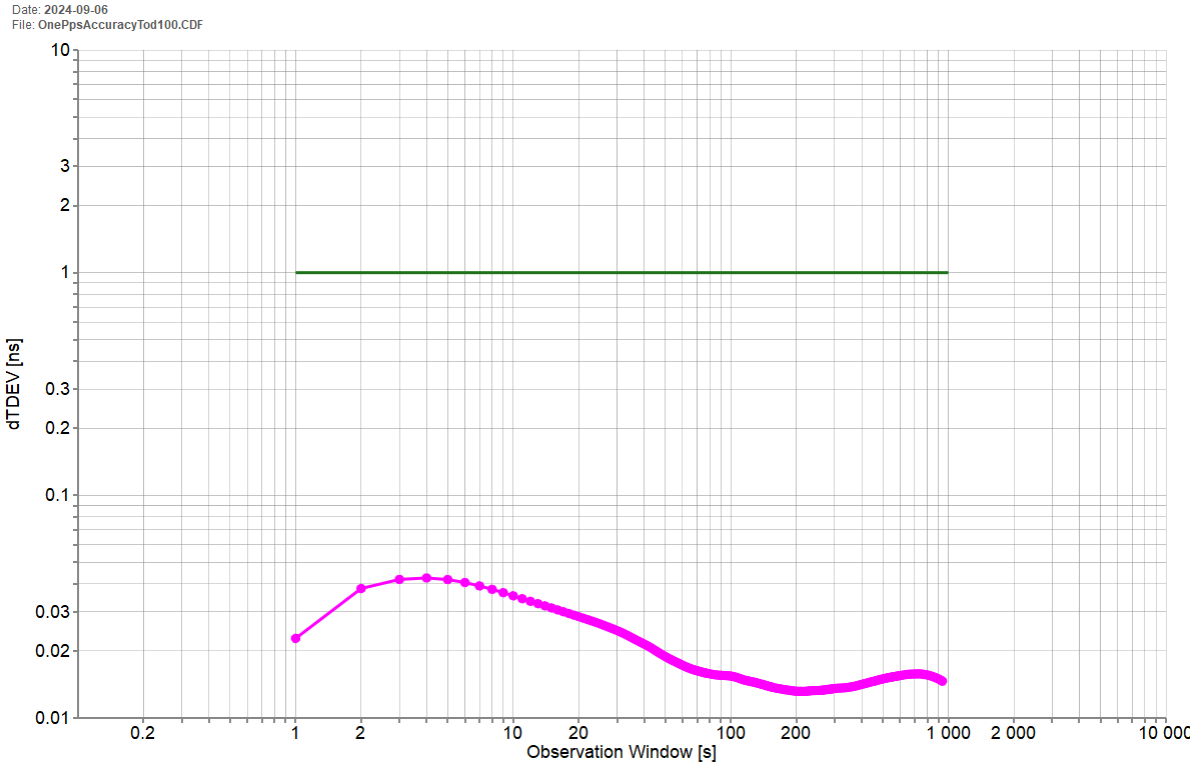
Mean [ns]	0
Min [ns]	-0.321
Max [ns]	0.377
Max-Min [ns]	0.698

5.1.2.6 DTEMTIE Analysis



Min [ns]	0.161
Max [ns]	0.403
Max-Min [ns]	0.242

5.1.2.7 DTETDEV Analysis



Min [ns]	0.013
Max [ns]	0.043
Max-Min [ns]	0.029

5.2 G.8273.2: Holdover

Holdover performance is checked by measuring the phase/time output in the event of the loss of the PTP input to the T-BC. The holdover performance is measured on PTP and 1PPS outputs of the DUT.

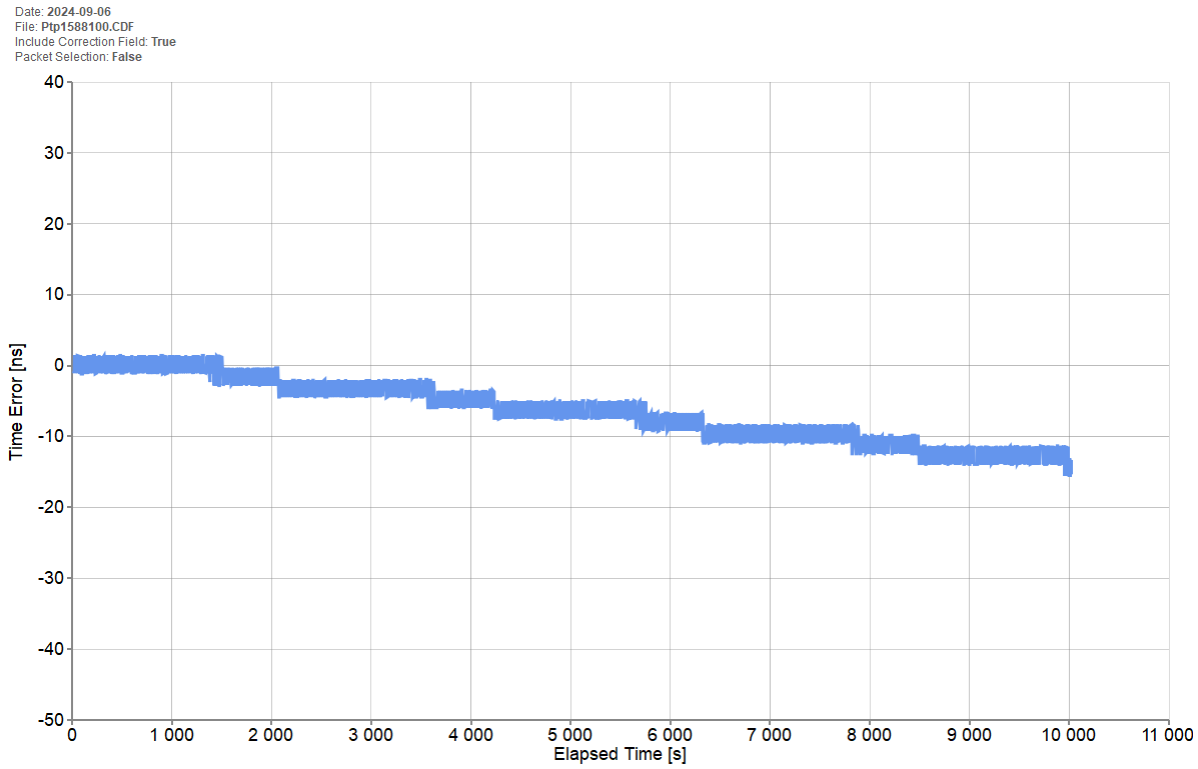
In this section, the external servo configuration (pcm4l, ptp4l, synced) is tested for conformance to ITU-T G.8273.2 Section 7.1 Class D. Physical layer assistance (SyncE) is used during this test.

5.2.1 PTP Measurements

Test Description	Holdover
Report Date	24-09-09_08-03-38
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 8:56:58 PM
Test Duration	62:31:01

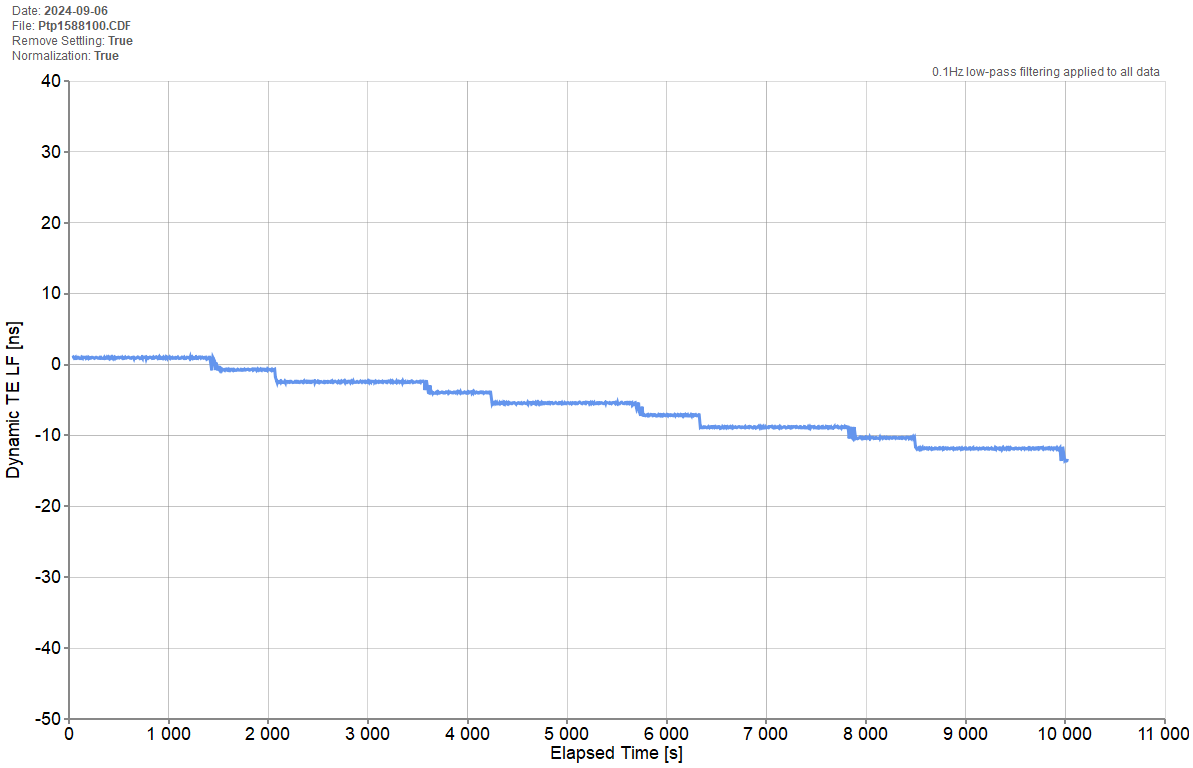
All Mask Results	**Pass**
Mask TIMEERROR	N/A
Mask TIMEERROR Result	NoMask
Mask DTE	N/A
Mask DTE Result	NoMask
Mask DTEMTIE	G.8273.2 T-BC Class B Time Holdover Const. Temp.
Mask DTEMTIE Result	**Pass**

5.2.1.1 TIMEERROR Analysis



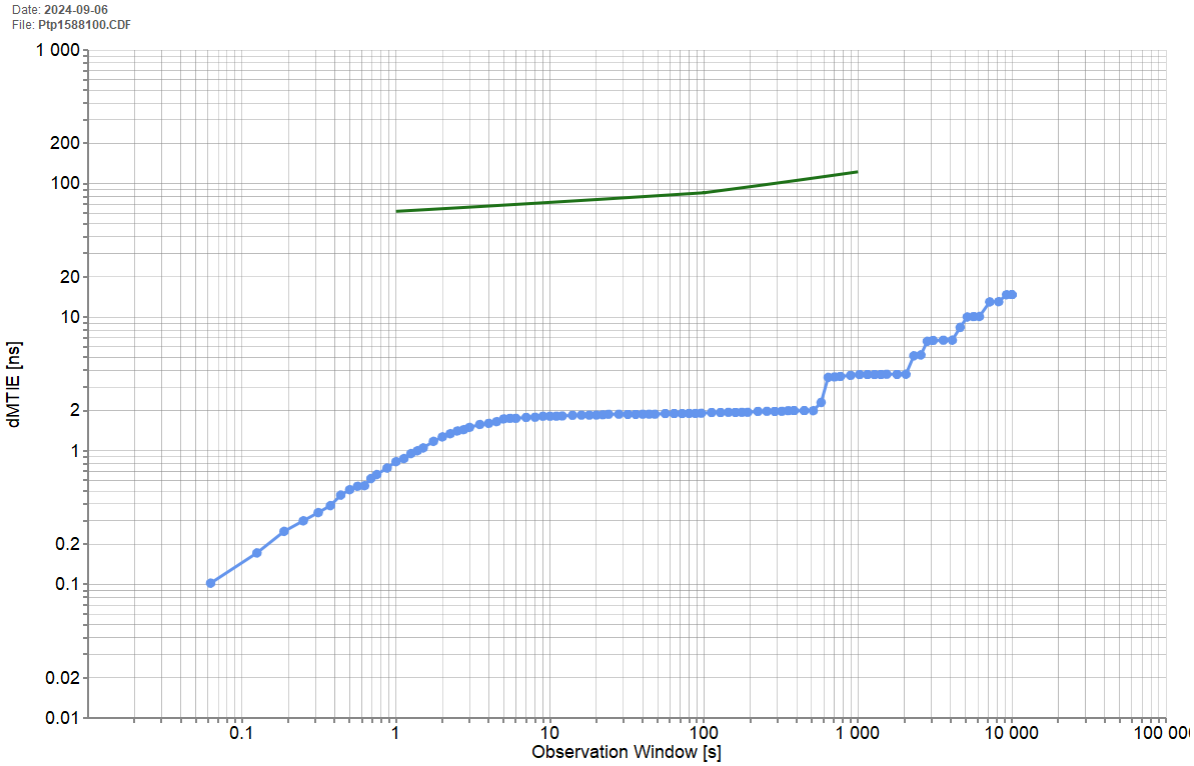
Pk-Pk [ns]	17.125
Mean [ns]	-6.423
Min [ns]	-15.698
Max [ns]	1.427

5.2.1.2 DTE Analysis



Mean [ns]	-5.608
Min [ns]	-13.617
Max [ns]	1.104
Max-Min [ns]	14.721

5.2.1.3 DTEMTIE Analysis



Min [ns]	0.102
Max [ns]	14.721
Max-Min [ns]	14.619

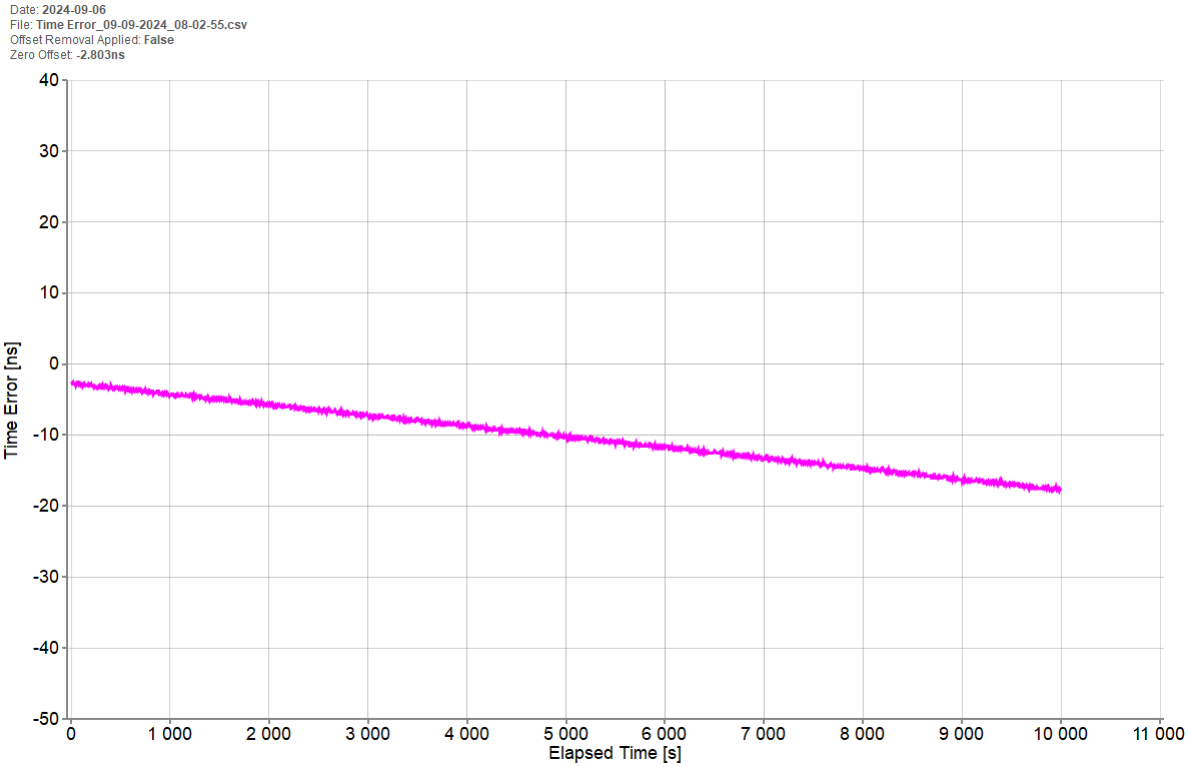
5.2.2 1PPS Measurements

Test Description	holdover
Report Date	24-09-09_08-03-38
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 8:56:58 PM
Test Duration	02:46:40

All Mask Results	**Pass**
Mask ONEPPS	N/A
Mask ONEPPS Result	NoMask
Mask MTIE	G.8273.2 T-BC Class B Time Holdover Const. Temp.
Mask MTIE Result	**Pass**

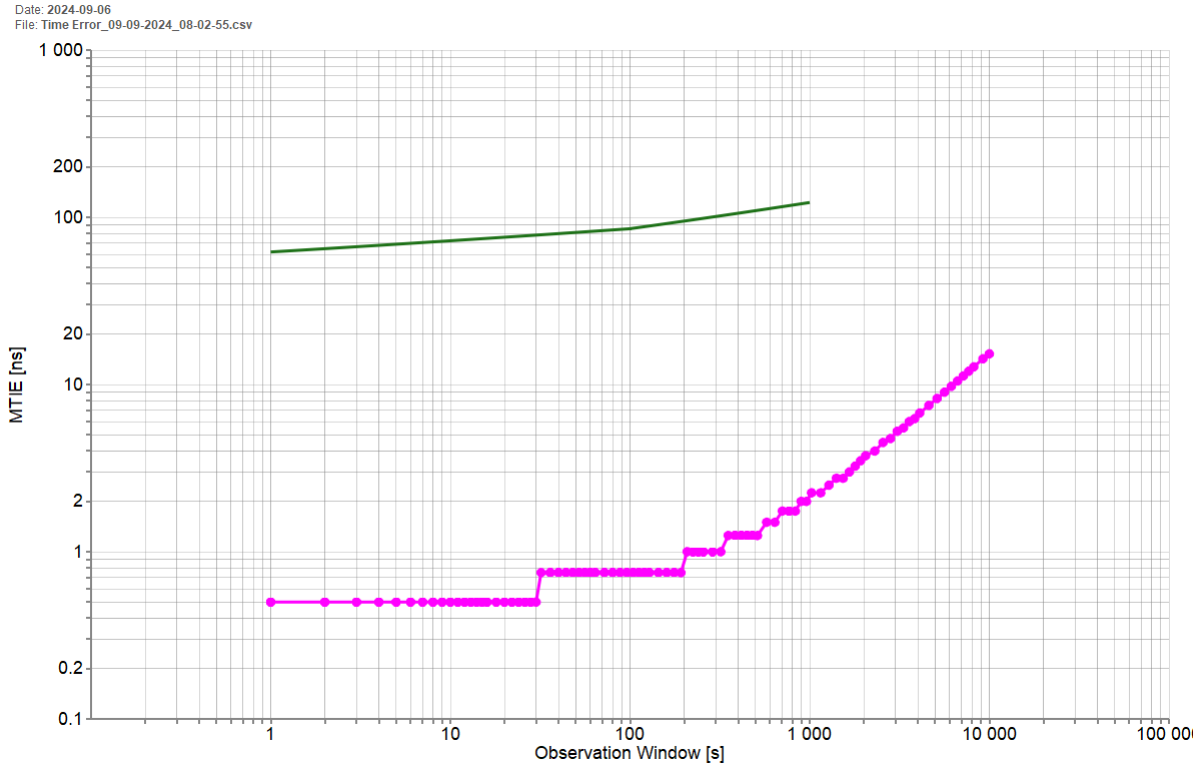
5.2.2.1 ONEPPS Analysis

Offset Removal Applied	Off
Zero Offset	-2.803 ns



Mean [ns]	-10.299
Min [ns]	-17.803
Max [ns]	-2.553
Max-Min [ns]	15.25

5.2.2.2 MTIE Analysis



Min [ns]	0.5
Max [ns]	15.25
Max-Min [ns]	14.75

5.3 G.8273.2: SyncE to PTP Noise Transfer

According to ITU-T G.8273.2 Section 7.3.2, the output PTP signal and 1 PPS signal must correspond to the input physical layer frequency input signal on which a band-pass filter whose lower corner frequency is between 0.05Hz and 0.1Hz and whose upper corner frequency is between 1Hz and 10Hz has been applied. This test checks whether T-BC under evaluation meets this bandpass filter requirement by adding sinusoidal noise on the SyncE (physical layer) input and measuring the output PTP noise amplitude.

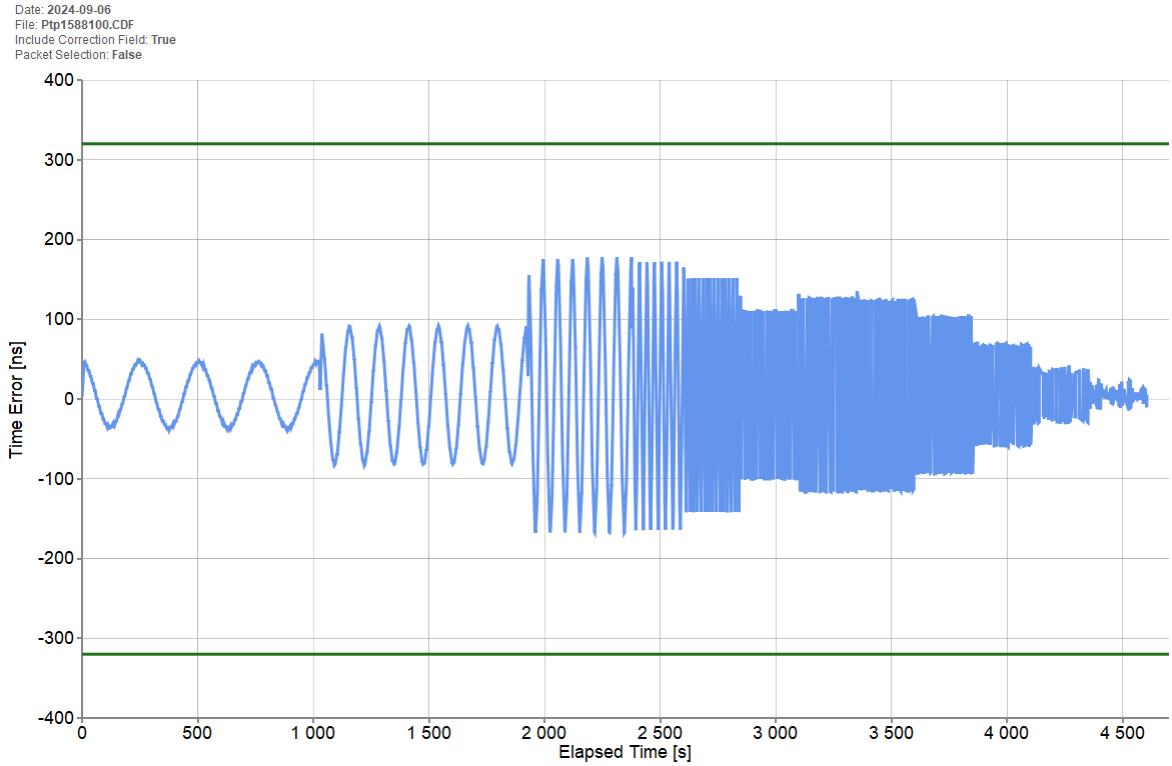
In this section, the external servo configuration (pcm4l, ptp4l, synced) with physical later assistance (SyncE) is tested for conformance.

5.3.1 PTP Measurements

Test Description	SyncE to PTP Noise Transfer
Report Date	24-09-06_16-56-06
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 7:20:38 PM
Test Duration	01:16:45
Time to Phase Lock (s)	8

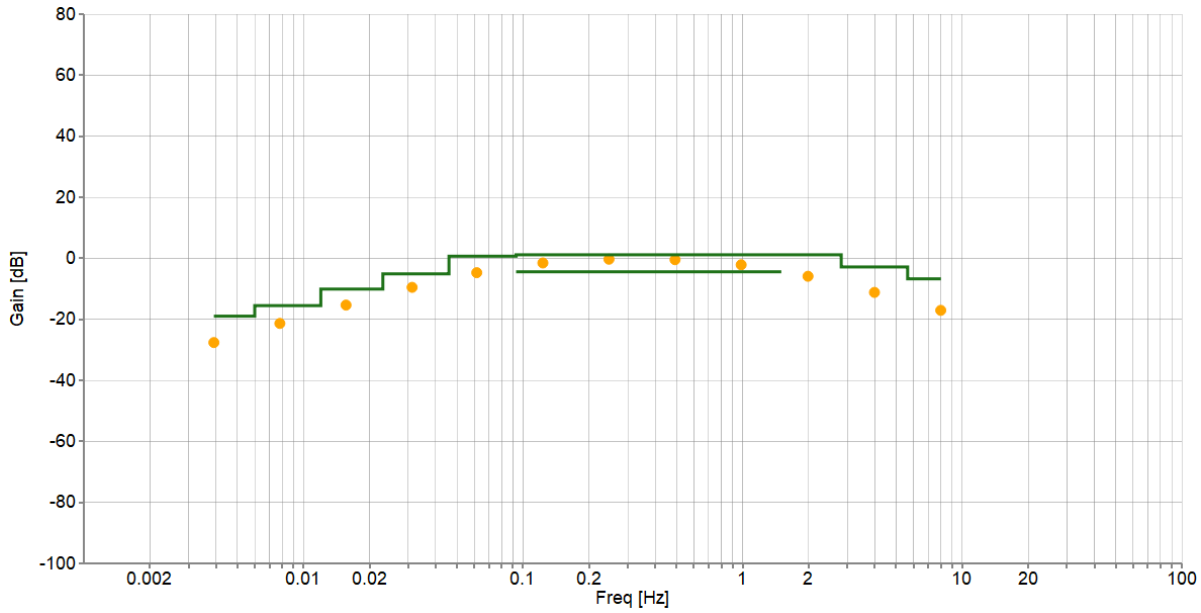
All Mask Results	**Pass**
Mask TIMEERROR	0.32µs
Mask TIMEERROR Result	**Pass**
Mask SyncENoiseTransfer	G.8273.2 Class C T-BCs Noise Transfer
Mask SyncENoiseTransfer Result	**Pass**

5.3.1.1 TIMEERROR Analysis



Pk-Pk [ns]	345.75
Mean [ns]	4.81
Min [ns]	-167.954
Max [ns]	177.796

5.3.1.2 SyncENoiseTransfer Analysis



Point #	Freq (Hz)	Ampl (ns)	Duration (s)	Pk-Pk Output (ns)	Gain (dB)	Upper Pk-Pk Limit (ns)	Lower Pk-Pk Limit (ns)
1	0.00391	2000	1023.02	83.06	-27.63	**225**	-
2	0.00781	2000	896.29	171.05	-21.36	**340**	-
3	0.01563	2000	447.86	341.71	-15.35	**630**	-
4	0.03125	1000	224.00	333.55	-9.54	**565**	-
5	0.06156	500	243.66	290.01	-4.73	**545**	-
6	0.12313	250	251.77	209.29	-1.54	**285**	**150**
7	0.24625	250	251.78	241.07	-0.32	**285**	**150**
8	0.4925	250	249.75	236.80	-0.47	**285**	**150**
9	0.985	250	249.75	195.31	-2.14	**285**	**150**
10	1.985	250	249.87	126.64	-5.91	**285**	-
11	3.985	250	249.94	68.87	-11.20	**285**	-
12	7.985	250	249.97	34.97	-17.08	**285**	-

5.4 G8273.2: SyncE to 1PPS Noise Transfer

According to ITU-T G.8273.2 Section 7.3.3, the output 1PPS signal and 1 PPS signal must correspond to the input physical layer frequency input signal on which a band-pass filter whose lower corner frequency is between 0.05Hz and 0.1Hz and whose upper corner frequency is between 1Hz and 10Hz has been applied. This test checks whether T-BC under evaluation meets this bandpass filter requirement by adding sinusoidal noise on the SyncE (physical layer) input and measuring the output 1PPS noise amplitude.

In this section, the external servo configuration (pcm4l, ptp4l, synced) with physical later assistance (SyncE) is tested for conformance.

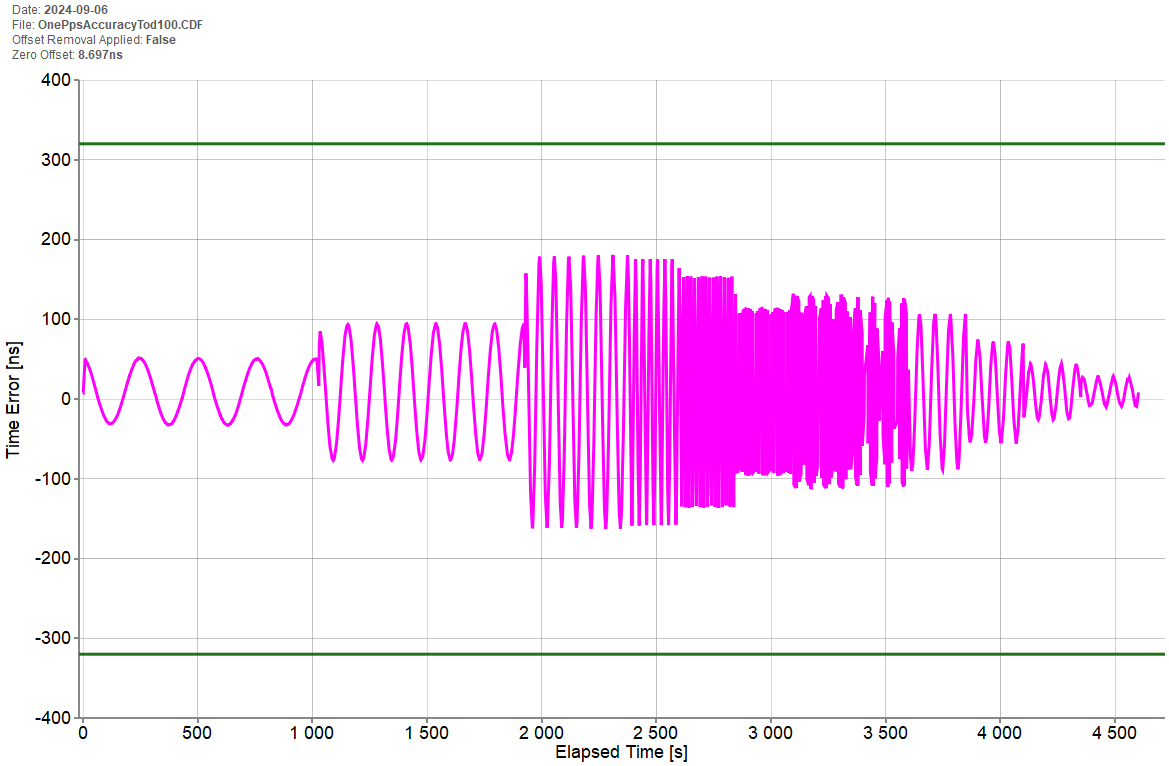
5.4.1 1PPS Measurements

Test Description	SyncE to 1PPS Noise Transfer
Report Date	24-09-06_16-56-06
Packet Rate (pkt/s)	16
Beginning of Test	9/6/2024 7:20:38 PM
Test Duration	01:16:42
Time to Phase Lock (s)	8

All Mask Results	**Pass**
Mask ONEPPS	0.32µs
Mask ONEPPS Result	**Pass**
Mask SyncENoiseTransfer	G.8273.2 Class C T-BCs Noise Transfer
Mask SyncENoiseTransfer Result	**Pass**

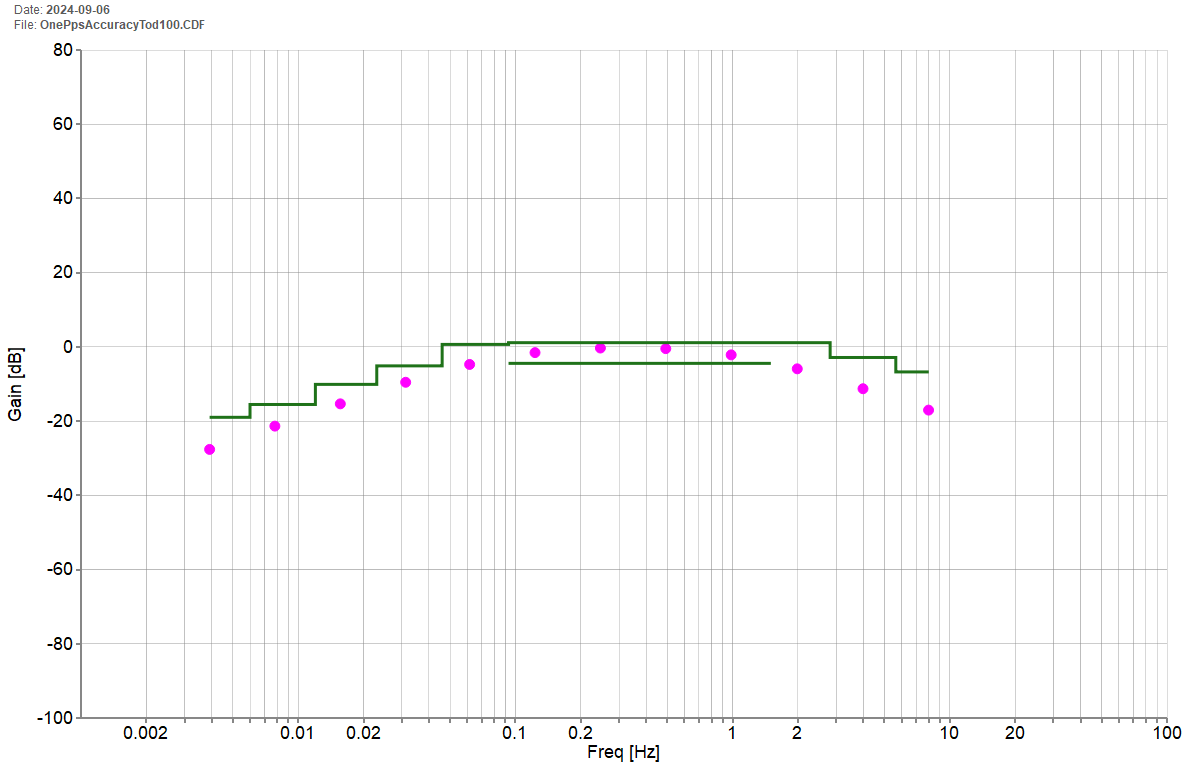
5.4.1.1 ONEPPS Analysis

Offset Removal Applied	Off
Zero Offset	8.697ns



Mean [ns]	8.704
Min [ns]	-162.553
Max [ns]	180.447
Max-Min [ns]	343

5.4.1.2 SyncENoiseTransfer Analysis



Point #	Freq (Hz)	Ampl (ns)	Duration (s)	Pk-Pk Output (ns)	Gain (dB)	Upper Pk-Pk Limit (ns)	Lower Pk-Pk Limit (ns)
1	0.00391	2000	1023.02	83.10	-27.63	**225**	-
2	0.00781	2000	896.29	171.25	-21.35	**340**	-
3	0.01563	2000	447.86	341.68	-15.35	**630**	-
4	0.03125	1000	224.00	333.54	-9.54	**565**	-
5	0.06156	500	243.66	289.95	-4.73	**545**	-
6	0.12313	250	251.77	209.29	-1.54	**285**	**150**
7	0.24625	250	251.78	241.22	-0.31	**285**	**150**
8	0.4925	250	249.75	236.83	-0.47	**285**	**150**
9	0.985	250	249.75	195.16	-2.15	**285**	**150**
10	1.985	250	249.87	126.58	-5.91	**285**	-
11	3.985	250	249.94	68.28	-11.27	**285**	-
12	7.985	250	249.97	35.17	-17.04	**285**	-

6. Configuration Files

6.1 TCS File

The TCS file comes loaded with the ZCU670 image: ZCU670_8A34001_10G_2025june17.tcs.

6.2 Ts2phc cfg File

```
#
# Example:
# ./ts2phc -mqf zcu670_ts2phc.cfg
#

[global]
clock_servo nullf
first_step_threshold 0.000000001
step_threshold 0.000000001
ts2phc.extts_correction -434

# Sink - Timestamper
[/dev/ptp1]
ts2phc.master           0
ts2phc.channel          0

# Source - CM
[/dev/ptp0]
ts2phc.master           1
ts2phc.channel          2
```

6.3 Standalone ptp4l cfg File

```
#
# Telecom G.8275.1 T-TSC example configuration containing those attributes
# which either differ from the defaults or are relevant to the profile.
#
[global]
domainNumber    24

# Announce messages
announceReceiptTimeout  3
logAnnounceInterval     -3

delayAsymmetry  4

# Sync/Delay_Req/Delay_Resp messages - 16 packets-per-second, -4 = 16 PPS
logSyncInterval         -4
logMinDelayReqInterval  -4

# step_window is in units of sync packets
# 3 seconds:
#   @ 16 PPS, set to 96
#   @ 1  PPS, set to  6
step_window     96

clockClass      255
clockAccuracy   0xFE
timeSource      0xa0
maxStepsRemoved 255

offsetScaledLogVariance 0xffff

G.8275.defaultDS.localPriority  128
G.8275.portDS.localPriority     128
priority1       128
priority2       255

dataset_comparison      G.8275.x
transportSpecific       0
clock_type      BC
delay_mechanism E2E


first_step_threshold    0.000020000
step_threshold          0.000020000
tx_timestamp_timeout    1000

write_phase_mode        1
servo_offset_threshold  580
servo_num_offset_values 128
tsproc_mode             raw

network_transport       L2
```

```
# 01:1B:19:00:00:00     Forwardable multi-cast address
# 01:80:C2:00:00:0E     Non-forwardable multi-cast address
ptp_dst_mac             01:1B:19:00:00:00

[eth1]
[eth2]
```

6.4 External Servo ptp4l cfg File

```
#
# PCM4L
#
# Telecom G.8275.1 T-TSC example configuration containing those attributes
# which either differ from the defaults or are relevant to the profile.
#
[global]
domainNumber    24

# Announce messages
announceReceiptTimeout  3
logAnnounceInterval     -3

# Sync/Delay_Req/Delay_Resp messages - 16 packets-per-second, -4 = 16 PPS
logSyncInterval         -4
logMinDelayReqInterval  -4

slaveOnly       0
masterOnly      0

clockClass      248
clockAccuracy   0xFE
timeSource      0xa0
maxStepsRemoved 255

offsetScaledLogVariance 0xffff

G.8275.defaultDS.localPriority  128
G.8275.portDS.localPriority     128

priority1       128
priority2       255

dataset_comparison      G.8275.x
transportSpecific       0

clock_type      BC
delay_mechanism E2E

#
# Send timestamps to pcm4l
#
free_running            1
```

```
slave_event_monitor     /var/run/pcm4l
tsproc_mode             raw
tx_timestamp_timeout    5
sanity_freq_limit       0


network_transport       L2

# 01:1B:19:00:00:00     Forwardable multi-cast address
# 01:80:C2:00:00:0E     Non-forwardable multi-cast address
ptp_dst_mac             01:1B:19:00:00:00

[eth1]
[eth2]
```

6.5 Pcm4l json File


```
{
  "versionId": "0.0",
  "testModeEnable": 0,
  "referenceTrackerType": "WritePhase",
  "remoteUdsAddress": "/var/run/ptp4l",
  "localUdsAddress": "/var/run/pcm4l",

  "stepWindowSeconds": 1,

  "phc4lConfig":
  {
      "dcoDevice": "/dev/ptp0",
      "tsDevice":
      [
          {
              "tsDeviceName": "/dev/ptp1",
              "tsDevicePinIndex": -1,
              "tsDeviceExttsChannel": 0,
              "tsDeviceExttsCorrectionNs": -434
          }
      ],
      "charDevice": "/dev/rsmu0",

      "phaseSnapDelaySeconds": 3,
      "tsCalibrationEnable": 0
  },

  "deviceConfig":
  {
      "oscillatorType": "Tcxo",
      "dpll1588Instance": 2,
      "tsDeviceAlignmentDisable": 0,
      "holdover":
      {
          "holdoverType": "HardwareEnhanced",
```

```
        "holdoverLossPhysicalOosEnable": 0,
        "holdoverTimeoutSeconds": 1000,
        "holdoverQualificationSeconds": 1000,
        "unqualifiedTimeoutSeconds": 10000,
        "outOfSpecUserDefinedFrequencyOffsetEnable": 0,
        "outOfSpecUserDefinedFrequencyOffsetPpb": 0
    }
},

"profileConfig":
{
    "physicalPllClockCategory": 4,
    "physicalPllClockCategoryThreshold": 1,
    "physicalPllInstance": 0,
    "physicalPllWaitToRestoreTimeoutValue": 10
},

"loggerConfig":
{
    "stdoutLog":
    {
        "enable": 1,
        "selectionMask": "0000000000111111",
        "_description_": "        | ||||||___ 0: Sync error                ",
        "_description_": "        | |||||____ 1: Sync warning              ",
        "_description_": "        | ||||_____ 2: Sync analysis             ",
        "_description_": "        | |||______ 3: Error                     ",
        "_description_": "        | ||_______ 4: Warning                   ",
        "_description_": "        | |________ 5: Debug                     ",
        "_description_": "        |__________ 7: Timestamp                 "
    },

    "externalFdLog":
    {
        "enable": 0,
        "selectionMask": "0000000000111111",
        "_description_": "        | ||||||___ 0: Sync error                ",
        "_description_": "        | |||||____ 1: Sync warning              ",
        "_description_": "        | ||||_____ 2: Sync analysis             ",
        "_description_": "        | |||______ 3: Error                     ",
        "_description_": "        | ||_______ 4: Warning                   ",
        "_description_": "        | |________ 5: Debug                     ",
        "_description_": "        |__________ 7: Timestamp                 "
    }
},

"instanceConfig":
[
    {
        "correctionFieldEnable": 1,
        "lostMasterTimeoutMilliseconds": 2000,
        "manageClockClassExtendedEnable": 0,
        "numberOfTrackerInstances": 1,
```

```
          "trackerConfig":
          {
            "delayAsymmetryNanoseconds": 0,
            "phaseSnapThresholdSeconds": 0.00001,
            "floorDelayEstimateSeconds": -1.0,
            "__timeLockThresholdNanoseconds": "Set to 200 to meet enhanced SyncE
limits",
            "timeLockThresholdNanoseconds": 580,
            "willCorrectFrequencyAtFirstSnap": 1,
            "frequencyLockThresholdPpb": 16.0,
            "lockFilterWindowLengthSeconds": 1.0
          }
      }
  ]
}
```

6.6 Synced cfg File

```
#
# Global parameters
#
[global]
net_opt 1
no_ql_en 0
synce_forced_ql_en 1
lo_ql SEC
lo_pri 255
max_msg_lvl 6
stdout_en 1
syslog_en 0
# Device configuration file path (applicable for generic device)
device_cfg_file ""
device_name /dev/rsmu0
synce_dpll_idx 0
holdover_ql SEC
holdover_tmr 10
hoff_tmr 300
wtr_tmr 10
advanced_holdover_en 0
pcm4l_if_en 1
pcm4l_if_ip_addr 127.0.0.1
pcm4l_if_port_num 2400
mng_if_en 1
mng_if_ip_addr 127.0.0.2
mng_if_port_num 2401

#
# Sync-E clock port
#
[eth1]
clk_idx 1
pri 1
tx_en 1
rx_en 1
tx_bundle_num -1
init_ql SEC

[eth2]
#clk_idx 1
pri 2
tx_en 1
rx_en 1
tx_bundle_num -1
init_ql SEC
```

7. Revision History

Revision	Date	Description
1.01	Sep 16, 2025	Updated Configuration Files section to reflect new recommended values for ZCU670.
1.00	Dec 11, 2024	Initial release.

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