

Time Error Simulator User Manual

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1 Introduction

Time Error Simulator software (SW) is a convenient tool designed to quickly simulate and analyze the impact of the local oscillator performance on various applications such as IEEE 1588 and SyncE.

It allows system simulation for locked state, providing an estimation of time and frequency errors, MTIE, and TDEV. The SW also provides the ability to recognize various causes of performance degradation including contributors such as temperature, drift and clock wander.

This tool simplifies and speeds time error estimation for the system and eliminates the need to perform long tests over many conditions and configurations. Only two basic tests (behavior over temperature and short-term frequency stability) and the drift specification of the local oscillator are needed to simulate time error for a wide range of scenarios. These scenarios include different system configurations (loop bandwidth, loop order), different conditions (temperature profile, locked state, holdover state) and different modes (PTP Only, PTP + SyncE).

2 Quick Start Guide

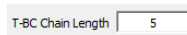
To quickly run the software, complete each of the steps below:

1. Select Simulation Mode:

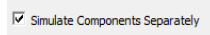
- a. PTP Only
- b. Hybrid Mode (PTP + SyncE)



2. Define Telecom Boundary Clocks (T-BC) Chain Length. Available only for 1.b selection. Note: it will default to a value of 1 for 1.a.

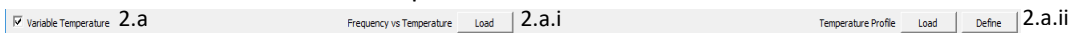


3. Enable/disable Simulate Components Separately for total time error components.



4. Complete at least one of the following:

- a. Enable Variable Temperature:
 - i. Load Frequency versus Temperature data
 - ii. Load or Define Temperature Profile



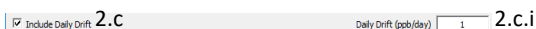
- b. Enable Include Clock Wander:

- i. Define Gate Time (used for frequency trend (frequency versus time) data collection)
- ii. Load Frequency Trend data



- c. Enable Daily Drift:

- i. Define Daily Drift value



5. Define System Loop parameters:

- a. PTP Loop Bandwidth (for 1.a and 1.b)
- b. PTP Filter Order (for 1.a and 1.b)
- c. SyncE Loop Bandwidth (for 1.b only)
- d. SyncE Filter Order (for 1.b only)



6. Define Carrier Frequency value.

Carrier Frequency (MHz)

7. If 2.a is disabled define Simulation Duration.

Simulation Duration (s)

8. Define the path and filename base to store the simulation results.

Save path and filename base

9. Press RUN button to perform simulation.

RUN Locked State Simulation

The progress bar will display the progress of the simulation. After the simulation completion, the results will be displayed in the “Results” section of the window and stored at the defined location.

3 Software

3.1 Description

Time Error Simulator Features:

1. Offers PTP Only simulation for system locked state. Simulation of a single node is supported.
2. Offers Hybrid mode (PTP + SyncE) simulation for system locked state. Simulation of a single node or chain of boundary clocks is supported.
3. Simulates the impact of temperature, clock wander, and drift (aging), in any combination.
4. Provides simulation results for system time error, frequency error, MTIE, and TDEV.

SW Input and Options:

1. Simulation mode selection:
 - a. PTP Only
 - b. Hybrid (PTP + SyncE)
2. Telecom Boundary Clocks (T-BC) Chain Length definition (for hybrid-mode only). For PTP Only mode, the value is always 1.
3. Simulation selection for total time/frequency error or total error plus error caused by each contributor separately. Enabling the simulation for each contributor will increase the simulation time by the number of contributors that are selected.
4. Temperature contribution analysis. This can be either included or excluded from analysis, and is enabled by default:
 - a. Input the CSV file with a frequency versus temperature curve of the analyzed oscillator device. Refer to the File Formats Section for the details on proper file formatting.
 - b. Temperature profile (temperature versus time). Two options are available for its definition:
 - i. As a CSV input file. Refer to the File Formats Section for the details on proper file formatting.
The profile time step defines the simulation data sample rate. If Clock Wander is included in the analysis (see item 2b below), then the profile time step must be

equal to the gate time used for the frequency trend measurement. The profile time step must be equal or less than 0.1 s for proper MTIE/TDEV simulation. The data sample rate must also be at least 2 times higher than the system loop bandwidth.

ii. Generated by SW. Such temperature profile parameters has to be defined (see figure 1):

1. Temperature offset ($^{\circ}\text{C}$)
2. Temperature amplitude ($^{\circ}\text{C}$)
3. Temperature starting point ($^{\circ}\text{C}$)
4. Temperature starting direction:
 - a. Up
 - b. Down
 - c. Dwell
5. Temperature ramp rate ($^{\circ}\text{C/s}$)
6. Dwell time (s)
7. Profile duration (s)
8. Profile time step (s). Default is 0.1s

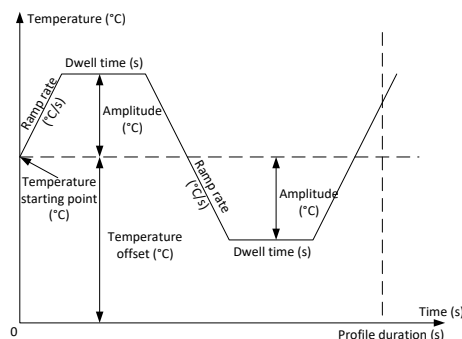


Figure 1: Temperature profile

5. Clock Wander contribution analysis can be either included or excluded from the simulation analysis. It can be disabled by default:
 - a. Frequency versus time trend. Refer to the File Formats Section for details on the proper file formatting. It is recommended to collect data in gap-free mode for at least 1 hour with a maximum gate time of 0.1 s.
 - b. Gate time used for trend data collection (s). The maximum gate time is 0.1 s.
6. Oscillator drift contribution analysis can be either included or excluded from analysis. It can be disabled by default:
 - a. Daily frequency drift (ppb/day)
7. Locked state simulation:
 - a. PTP Only mode:
 - i. PTP loop filter bandwidth (Hz; default is 0.1 Hz).
 - ii. PTP filter order (default is 2nd, must be ≥ 2)
 - b. Hybrid (PTP + SyncE) mode:
 - i. PTP loop filter bandwidth (Hz; default is 0.1 Hz).
 - ii. PTP filter order (default is 2nd, must be ≥ 2)

- iii. SyncE loop filter bandwidth (Hz; default is 1 Hz).
 - iv. SyncE filter order (default is 2nd, must be ≥ 2)
- 8. Carrier frequency (MHz).
- 9. Simulation duration. If the temperature profile is defined, the simulation duration is automatically set to be equal to the profile duration.
- 10. Save file path and filename base.

SW Output:

1. Time error versus time:
 - a. Total time error plot (summary of all contributors) is shown on the GUI.
 - b. Time error plots by each contributor selected for analysis can be shown in separate windows. Note: contributors separate simulation must be enabled.
 - c. All plots and simulation data (by summary and by each contributor separately) are saved to CSV and PNG files respectively. Refer to the File Formats Section for details on proper file formatting.
2. Frequency error versus time:
 - a. Total frequency error plot (summary of all contributors) is shown on the GUI.
 - b. Frequency error plots for each contributor selected for analysis can be shown in separate windows. Note: Contributors Separate Simulation must be enabled.
 - c. All plots and simulation data (by summary and by each contributor separately) are saved to CSV and PNG files respectively. Refer to the File Formats Section for more details.
3. MTIE versus time:
 - a. Summary MTIE plot (summary of all contributors) is shown on the GUI.
 - b. MTIE plots by each contributor selected for analysis can be shown in separate windows. Note: contributors separate simulation must be enabled.
 - c. All plots and simulation data is saved to CSV and PNG files respectively. Refer to the File Formats Section for more details.
4. TDEV versus time:
 - a. Summary TDEV plot (summary of all contributors) is shown on the GUI.
 - b. TDEV plots by each contributor selected for analysis can be shown in separate windows. Note: contributors separate simulation must be enabled.
 - c. All plots and simulation data is saved to CSV and PNG files respectively. Refer to the Files Formats Section for more details.

Figure 2 shows the SW at startup. Refer to Appendix A for example screenshots of the SW after performing the simulation.

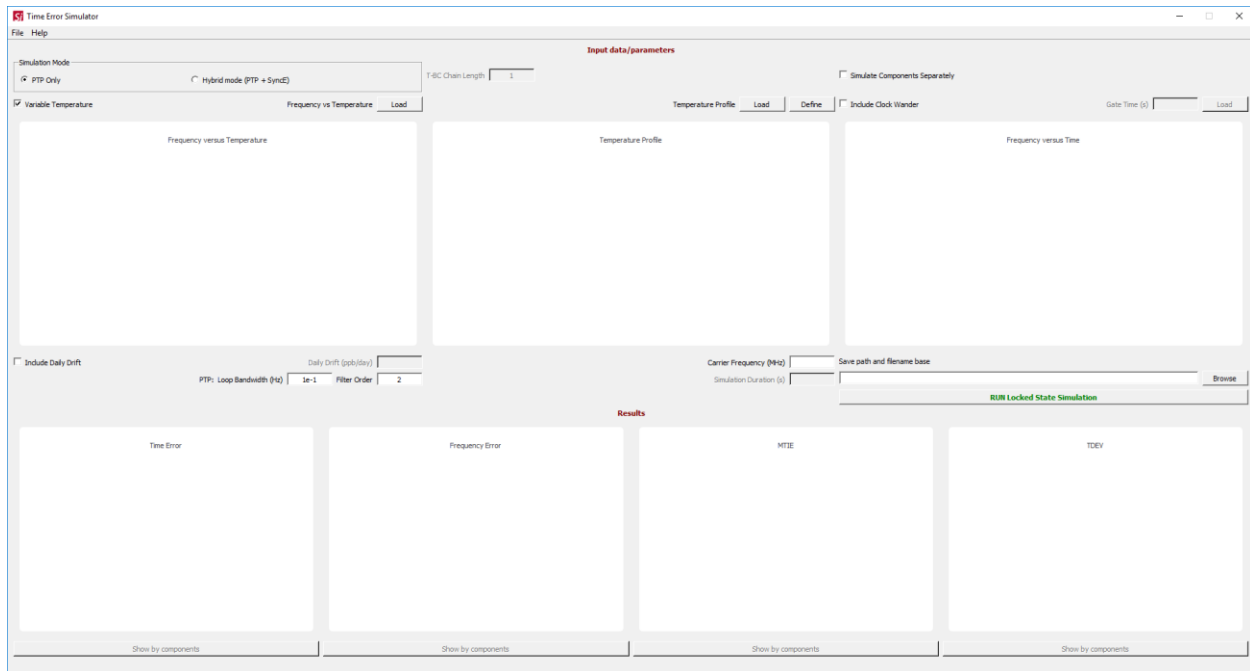


Figure 2: SW startup appearance

3.2 Software Download and Launch

SiTime Time Error Simulator can be downloaded from SiTime website in both [32-bit](#) and [64-bit](#) versions. The software package will be downloaded as ZIP archive (*Time-Error-Simulation-by-SiTime-(x86).zip* or *Time-Error-Simulation-by-SiTime-(x64).zip*). The user will need to unpack files to target location on their PC.

The unpacked folder will contain two sub-folders:

1. *Manual* – contains SW manual
2. *TimeErrorSimulator* – includes software executable file.

To start the SW, launch the *TimeErrorSimulator.exe* (located in *TimeErrorSimulator* folder).

3.3 Software Requirements

Time Error Simulator requirements:

1. Windows 7 or Windows 10 operating system
2. At least 1 GB of RAM available for application. For longer simulation time, additional memory will be required.

3.4 Software Controls

The following section outlines the control settings that enable the full software features. Note: all entry fields described below require all values in range of -1 to 1 to be entered using engineering notation. For example value 0.1 should be entered as 1e-1.

3.4.1 Simulation Mode Selection

Radio buttons control the simulation mode with two options:

1. PTP Only mode
2. Hybrid (PTP + SyncE) mode

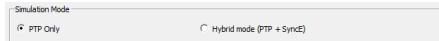


Figure 3: Simulation mode selection

Note: PTP Only mode supports both locked state and holdover state simulation whereas Hybrid (PTP + SyncE) mode supports only locked state simulation.

3.4.2 T-BC Chain Length Definition

The Edit box is intended for Telecom Boundary Clocks (T-BC) chain length definition. It is available only for Hybrid simulation and defaults to 1 for PTP Only mode.



Figure 4: T-BC chain length definition

3.4.3 Separate Components Simulation

Software by default simulates total time/frequency error and MTIE/TDEV (which are a summary of all selected contributors). To simulate contribution of each component separately in addition to the summary effect, use the checkbox shown at figure 5 to enable/disable this feature. Note: enabling this option will increase the simulation time and memory needs by the number of components selected.

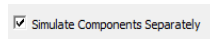


Figure 5: Enable/disable of components separate simulation

3.4.4 Temperature Contribution Analysis

For the temperature contribution analysis such controls are provided (see figure 6):

1. Check the box allowing include/exclude Variable Temperature from the analysis inputs. Note: this enabled by default.
2. Select the button for Frequency vs Temperature data load. Once selected, the SW prompts user to select file with data. Please refer to the Files Formats section for more details on frequency vs temperature data file formats. After the file is selected, the SW will load the data and plot it on the plot area.
3. The plot area is intended for displaying loaded frequency versus temperature data.



Figure 6: Temperature contribution analysis input data controls

4. Select the button for temperature profile data load. Once selected, the SW prompts the selection of the file with data. Please refer to the *Files Formats* Section for details on temperature profile data file formats. The SW will then load the data and plot it on the plot area. **Simulation duration is set equal to the temperature profile duration which is the last time point in the profile. The profile time step is calculated based on first two data points and has to be constant for all profile for proper simulation results**
5. Select the button for temperature profile definition. Once selected, the SW launches a new window (see figure 7) providing controls for profile definition:
 - a. Edit field for temperature offset (°C) definition.
 - b. Edit field for temperature amplitude (°C) definition.
 - c. Edit field for temperature starting point (°C) definition.
 - d. Radio button group for temperature starting direction.
 - i. Up
 - ii. Down
 - iii. Dwell
 - e. Edit field for temperature ramp rate (°C/s) definition.
 - f. Edit field for dwell time (s) definition.
 - g. Edit field for time step (s) definition. The default setting is 0.1 s. It is not recommended to set profile step higher than 0.1 s.
If Clock Wander contribution is enabled and frequency trend collection gate time is different from the profile time step, it will be re-calculated using gate time as a profile time step.

If the profile was loaded from CSV file, a warning message will appear (please refer to the Warning Messages section) and cancel simulation.

Profile time step and gate time define data sample rate for simulation. Data sample rate has to be at least 2 times higher than filter loop bandwidth (applies only to locked state simulation)

- h. Edit field for profile duration (s) definition. **Simulation duration is equal to the temperature profile duration.**

Based on the entered parameters, the temperature profile is generated.

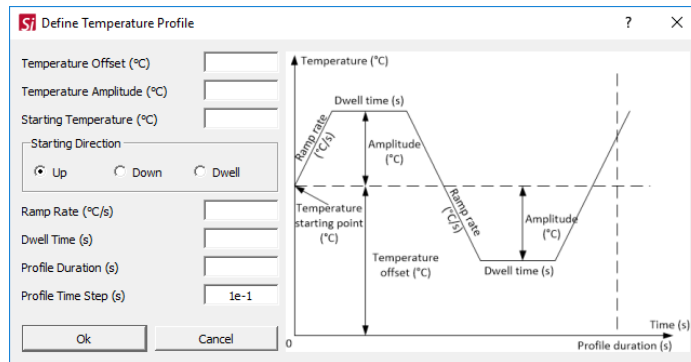


Figure 7: Temperature profile definition window

The following rules should be followed when defining the profile:

1. The Up direction starting point should be less than MAX profile temperature (which is offset temperature + amplitude).
2. The Down direction starting point should be higher than MIN profile temperature (which is offset temperature – amplitude). The Dwell direction starting point should be equal to either MIN or MAX profile temperature. The profile will start from the dwell with its duration defined by dwell duration parameter. The profile cannot start in the middle of the dwell period.

Note: Profile duration divided by profile time step defines the number of simulation data points. More data points will require more time and RAM for simulation.

3.4.5 Clock Wander Contribution Analysis

The following controls enable the clock wander contribution analysis (see figure 8):

1. Select the box allowing Include Clock Wander from the analysis inputs. This is disabled by default.
2. Edit the field for gate time definition (s). Gate time has to be 0.1 s or lower for the trend data collection. Profile time step and gate time define the data sample rate for simulation. Data sample rate has to be at least 2 times higher than filter loop bandwidth (this applies only to Locked State simulation).
3. Select button for frequency trend data load. After button is selected, the SW prompts a data file to be selected. Please refer to the *Files Formats* Section for frequency trend data file format. After file is selected, the SW loads the data and plots it on the plot area.
4. The plot area is intended for displaying the loaded frequency trend.

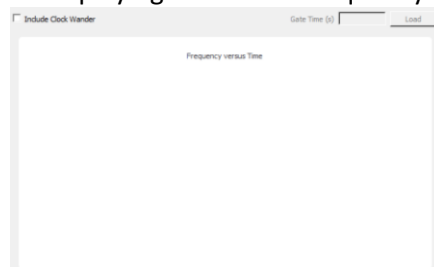


Figure 8: Clock wander contribution analysis input data controls

3.4.6 Daily Aging Contribution Analysis

The oscillator's daily aging contribution analysis controls are provided below (see figure 9):

1. Select the box allowing Include/ Daily Aging from the analysis inputs. This is disabled by default.
2. Edit the field for daily aging definition. The value should be entered in ppb per day.

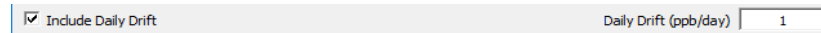


Figure 9: Daily drift parameters definition controls

3.4.7 Close Loop Simulation Parameters Definition

This section outlines the control values (see figure 10):

1. Edit the field for PTP loop bandwidth definition. The value must be entered in Hertz. The default is 0.1 Hz. This applies for both PTP Only and Hybrid simulation modes.
2. Edit the field for PTP filter order definition. The default and minimal allowed value is 2nd order. Only integer values are accepted. This applies for both PTP Only and Hybrid simulation modes.
3. Edit the field for SyncE loop bandwidth definition. The value must be entered in Hertz. The default is 1 Hz. This applies for Hybrid simulation mode only.
4. Edit the field for SyncE filter order definition. The default and minimal allowed value is 2nd order. Only integer values are accepted. This applies for Hybrid simulation mode only.



Figure 10: Closed loop parameters definition controls

3.4.8 General Parameters Definition

This section provides such controls (see figure 11):

1. Edit field for Carrier Frequency. The frequency must be entered in MHz units.
2. Edit field for Simulation Duration definition (in seconds). **If temperature profile is defined, this field gets disabled and the simulation duration is set equal to the profile duration.**
3. Edit field for save path and filename base definition. The user can either type or insert the path and file name base.
4. Select the Browse button. When selected, the SW prompts the user to enter a folder selection and name specification. The selected folder and filename will be displayed in the edit field.



Figure 11: General parameters definition controls

3.4.9 RUN Button

To start the simulation process, press RUN button. Based on simulation type selection RUN button will look differently (see figure 12). If any of input parameters is not entered correctly, an error will result and cancel the simulation. If none of contributors are enabled for analysis on SW, the simulation will be

cancelled. Once the simulation is finished, the results are plotted on the SW and the data is saved to the file (CSV) and the plots are saved as PNG files. Please refer to the *Files Formats* Section for the details on the saved data file format.



Figure 12: RUN button section

During the simulation, a progress bar will pop-up showing simulation current progress. Depending on the user's system theme, the simulation progress bar display may appear different (see figure 13).

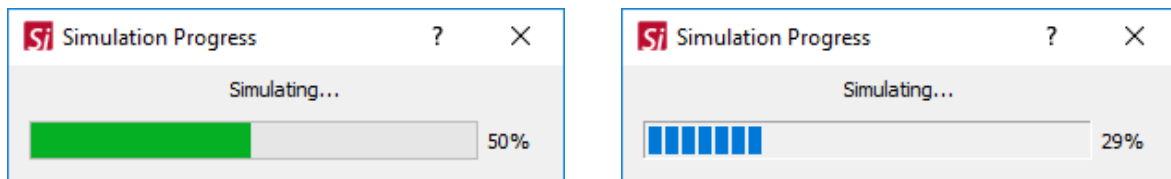


Figure 13: Simulation progress bar

3.4.10 Results Displaying Controls

The simulation results will be displayed at four plot areas (see figure 14):

From left to right:

1. The furthest left area displays the total time error results.
2. The next area displays total frequency error results.
3. The next area displays the MTIE results
4. The furthest rights area displays TDEV results.
5. The four buttons under each plot trigger plotting by contributors for each simulated parameters. These are enabled if separate contributor's simulation is enabled. Each plot will appear in a separate window.

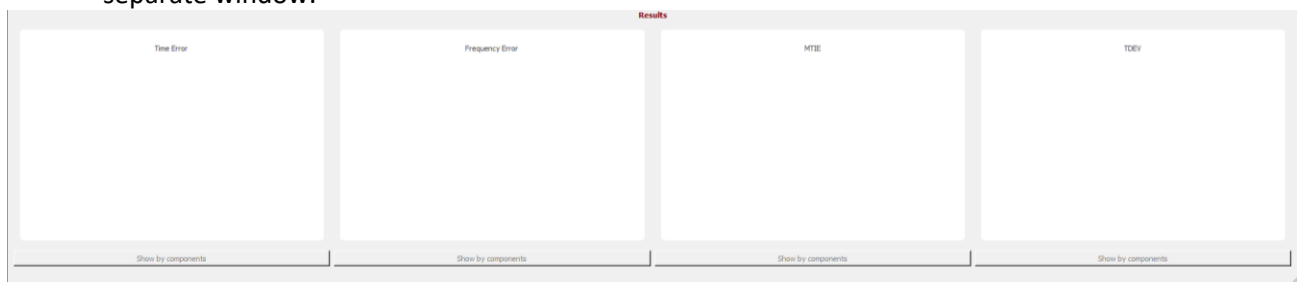


Figure 14: Results displaying controls

3.4.11 Menus

Two menu items are provided on the GUI (see figures 15-16):

1. The "File" menu contains:
 - a. "Close" – this closes application.
2. The "Help" menu contains:

- “About” – which opens the window showing SW version and contact information.
- “Open Manual” – which opens this manual.

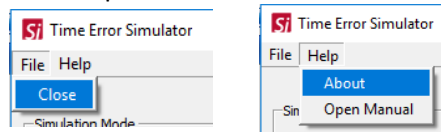


Figure 15: Menus

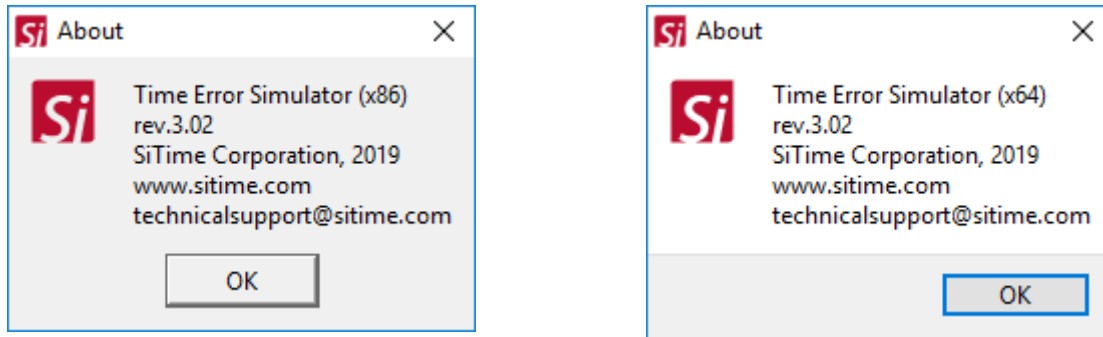


Figure 16: About window

3.4.12 Working with Plots

Zoom-in functionality is provided for the plots drawn on the GUI. To zoom-in, users must click and hold the left mouse button then drag drawing rectangle (see figure 17). After the button is released, the area under the rectangle will zoom-in. On right mouse button click plot will zoom out. A double click on the plot will reset the zoom functionality.

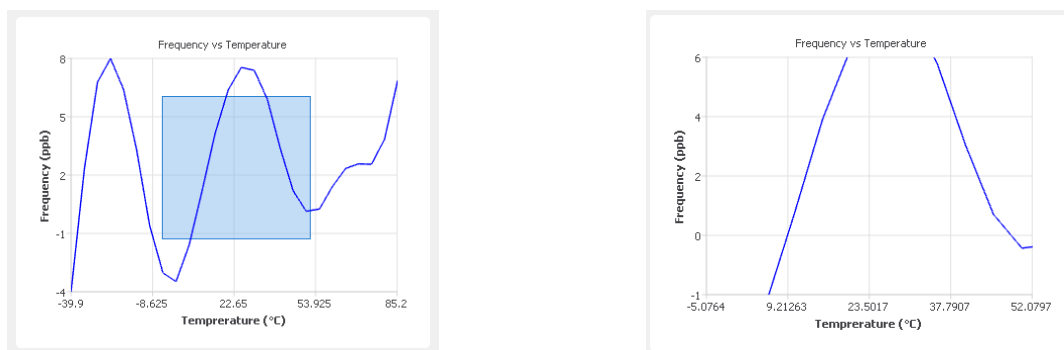


Figure 17: Zooming-in plots

Plots by contributors are opened in separate windows (once the corresponding button is pressed). These provide toolbars with zoom-in and reset zoom controls (see figure 18).

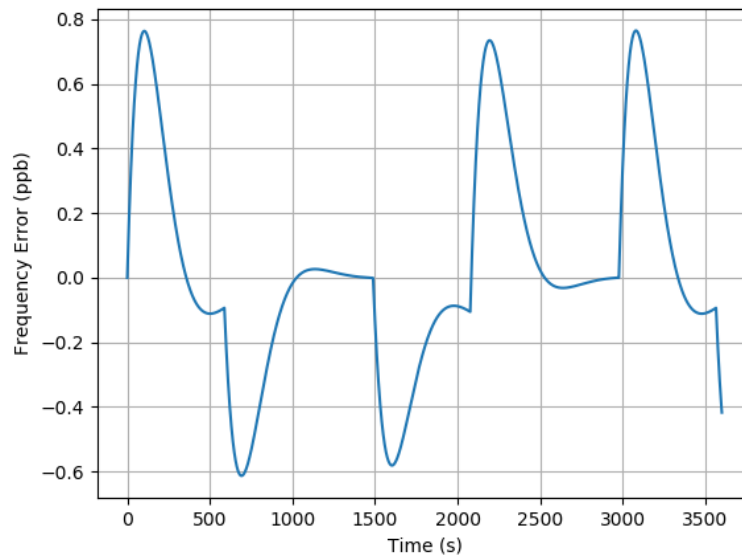
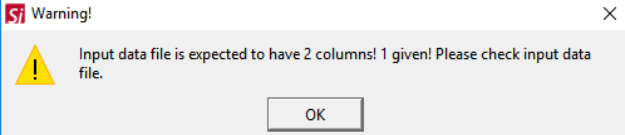
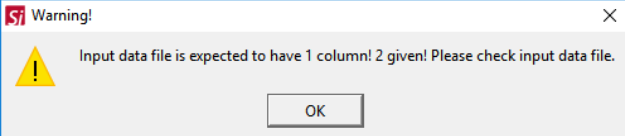
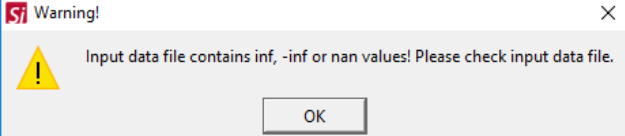
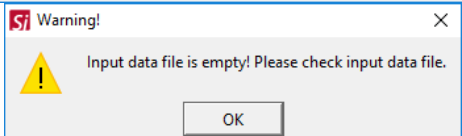
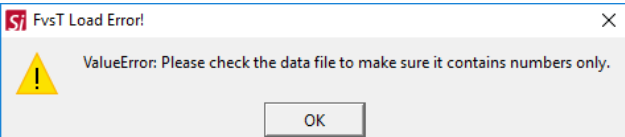
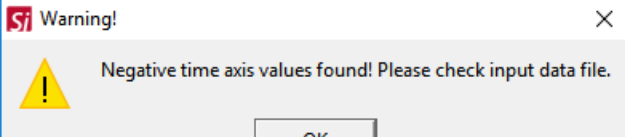
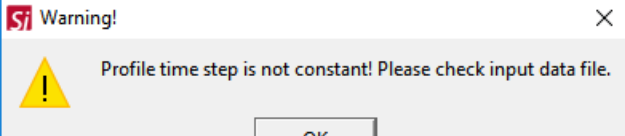
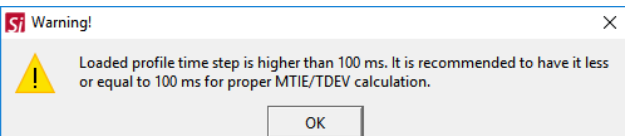
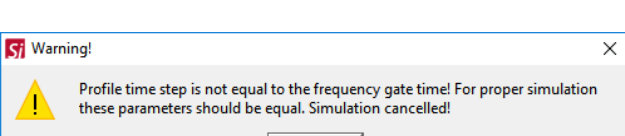


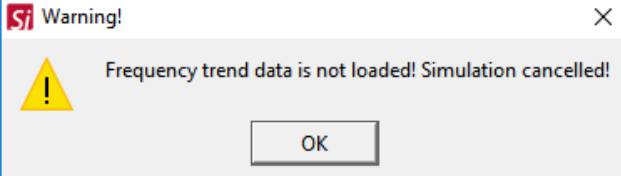
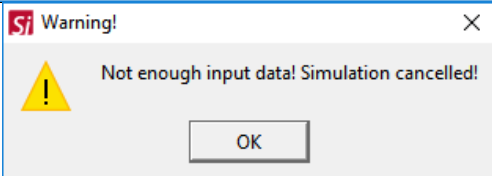

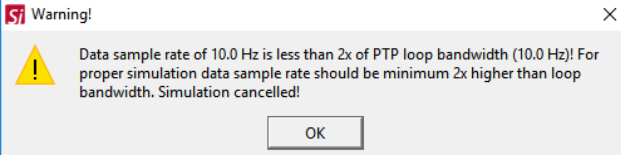
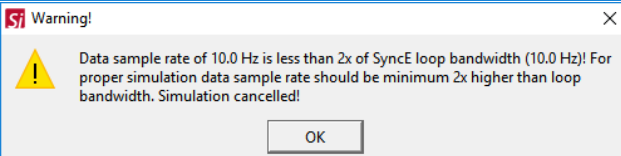
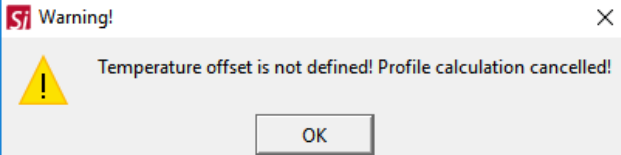
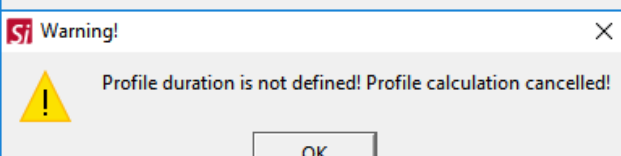
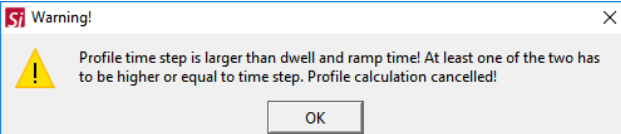
Figure 18: Plot showing simulated parameter by specific contributor

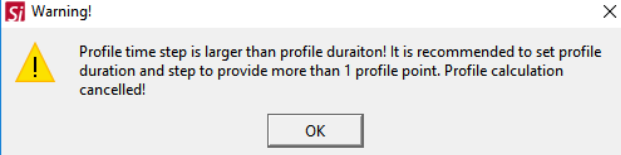
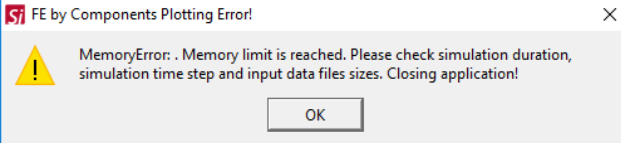
3.4.13 Warning and Error Messages

Table 1 summarized the various warning messages and provides the corresponding explanations.

Table 1. Warning/Error messages

Warning/Error Message	Description
   	<p>These warning messages will be prompted if wrong data file is selected. For example: when loading frequency versus temperature data SW will expect data file with two columns. If occasionally wrong file with one column will be selected SW will throw a warning. Please refer to the File Formats section for input file formats description.</p>
	<p>This error message will pop-up if there is non-number characters in the file being loaded.</p>
	<p>This warning will be prompted if selected profile data file will contain negative values in the time column.</p>
	<p>This warning will be prompted if selected profile data file will have different time step across time column. It is required to have profile data equally spaced in time.</p>
	<p>Notifies that profile time step is higher than recommended maximum of 0.1 s. Can appear when temperature profile data is loaded from the file.</p>
	<p>Notifies that profile time step is not equal to the gate time used for frequency trend collection. This warning appears only when the temperature profile is loaded from the file and Clock Wander contribution is included in analysis.</p>

	<p>Example warning message if some parameter is not defined correctly. Can appear after RUN button is pressed and input parameters are missing (for example: frequency trend data).</p>
	<p>This warning will appear if user attempts to run simulation without inputting the necessary contributors (temperature, clock wander and/or daily aging).</p>
	<p>This warning will appear if no file is selected for either frequency versus temperature, frequency trend or temperature profile load.</p>
 	<p>This warning will appear if data sample rate is less than 2x higher than loop bandwidth (either PTP or SyncE) and temperature and/or Clock Wander contributors are enabled. The data sample rate is defined by profile time step and/or gate time used for frequency trend collection. To avoid this error, data sample rate has to be more than twice higher than loop bandwidth.</p>
 	<p>Example warning messages for the case if some profile parameter is not defined. Can pop-up after OK button click in temperature profile definition window if some input parameters are missing (temperature offset/profile duration data in particular).</p>
	<p>General recommendation is to have profile time step to be less than duration of separate profile parts as ramp and dwell. Minimal requirement is to have duration of at least one of the two parts (ramp or dwell) to be higher than time step. If profile parameters will be defined so that ramp time and dwell time both are less than time step this warning will appear. At least minimal requirement described above has to be satisfied to overcome this warning.</p>

 <p>Warning!</p> <p>Profile time step is larger than profile duration! It is recommended to set profile duration and step to provide more than 1 profile point. Profile calculation cancelled!</p> <p>OK</p>	<p>This warning will appear if profile time step is set to be higher than profile duration. To have at least 1 profile point profile time step has to be less than or equal to profile duration.</p>
 <p>FE by Components Plotting Error!</p> <p>MemoryError: . Memory limit is reached. Please check simulation duration, simulation time step and input data files sizes. Closing application!</p> <p>OK</p>	<p>This error will appear if SW application will require more RAM memory than it can get from operating system. It might happen because of one or several of causes: loaded frequency trend is very long, simulation resolution is very low (which lead to many data points), ADEV step and/or simulation time is low (usually in combination with much longer frequency trend), etc.</p>

4 File Formats

This section describes input/output file formats.

4.1 Frequency versus Temperature

The *Frequency versus Temperature* data file must have a CSV format with two columns:

1. The first column must contain temperature data (°C)
2. The second column must contain frequency data (ppb)

-39.9	-4.1694
-34.8	2.3952
-29.8	6.9877
...	...

File should contain only numbers and should not be empty.

4.2 Temperature Profile

The *Temperature Profile* data file must have a CSV format with two columns:

1. The first must contain time data (S) and the time step should be constant.
2. The second column must contain temperature data (°C).

0	2
0.1	4
0.2	4
0.3	4
0.4	4
0.5	4
...	...

File should contain only numbers and should not be empty.

4.3 Frequency Trend

The *Frequency Trend* data file must have a CSV format with one column containing fractional frequency values (ppb).

-4.1694
-4.3694
-4.5494
-4.2394
-4.1645
-4.1364
...

File should contain only numbers and should not be empty.

4.4 Time Error versus Time

The *Time Error vs Time* data file must have a CSV format with a minimum of two columns:

1. The first column must contain time data (s).
2. The second column must contain total time error (ns)
3. All subsequent columns can contain time error (ns) for selected contributors (if the simulation is enabled):
 - a. Temperature
 - b. Clock Wander
 - c. Daily Aging

The first row of the file contains column labels.

Time (s)	Total Time Error (ns)	Time Error due to Temperature (ns)	Time Error due to Drift (ns)
0	2500.246	0	0
1	3029.882	0	0
2	1849.971	0.322077	5.79E-06
3	-2023.85	0.96623	2.31E-05
4	4292.388	1.610383	5.21E-05
5	-633.982	2.254537	9.26E-05
6	-869.131	2.89869	0.000145
7	7477.958	3.542843	0.000208
8	6175.033	4.186997	0.000284
9	-3253.56	4.83115	0.00037
10	1785.546	5.475303	0.000469
11	507.3034	6.119457	0.000579
...

The file name will have simulation mode, simulation type and data type attached to its base defined by user. For example:

TimeErrorSimulationTestHybridLockStateSimTimeError.csv

4.5 Frequency Error versus Time

The *Frequency Error vs Time* data file must have a CSV format with minimum two columns:

1. The first column must contains time data (s)
2. The second column must contains total frequency error (ppb)
3. All subsequent columns can contain frequency error (ppb) for selected contributors (if simulation is enabled):
 - a. Temperature
 - b. Clock Wander
 - c. Daily Aging

The first row of the file contains column labels.

Time (s)	Total Frequency Error (ppb)	Frequency Error due to Temperature (ppb)	Frequency Error due to Allan Deviation (ppb)
0.1	0	0	0
0.2	0.188271	0.019663	0.168608
0.3	0.238612	0.05928	0.17933
0.4	0.37286	0.099476	0.273381
0.5	0.356585	0.140244	0.216338
0.6	0.464421	0.181576	0.28284
0.7	0.521634	0.223466	0.298162
0.8	0.486475	0.265906	0.220562
0.9	0.535323	0.308889	0.226425
1	0.579686	0.352407	0.227269
1.1	0.63907	0.396453	0.242606
1.2	0.631181	0.44102	0.190148
...

The file name will have simulation type and data type attached to its base defined by user. For example:

TimeErrorSimulationTestHybridLockStateFreqError.csv

4.6 MTIE versus Time

The *MTIE vs Time* data file must have a CSV format with minimum two columns:

1. The first column must contain time data (s)
2. The second column must contain summary MTIE (ns)
3. All subsequent columns can contain MTIE (ns) for selected contributors (if simulation is enabled):
 - a. Temperature
 - b. Clock Wander
 - c. Daily Aging

The first row of the file contains column labels.

Time (s)	Summary MTIE (ns)	MTIE due to Temperature (ns)	MTIE due to Drift (ns)
0.1	0.221834	0.195107	5.28E-05
0.3	0.658723	0.584482	0.000158
0.5	1.088724	0.97274	0.000264
0.7	1.513723	1.359884	0.000369
1	2.139524	1.938511	0.000528
1.1	2.356075	2.130942	0.00058
1.3	2.779226	2.515304	0.000686
1.5	3.202239	2.898557	0.000792
1.8	3.82759	3.47136	0.00095
2	4.26214	3.851845	0.001055
2.5	5.325485	4.798234	0.001319
3	6.375664	5.737748	0.001583
...

The file name will have simulation type and data type attached to its base defined by user. For example:

TimeErrorSimulationTestPTPOnlyLockStateSimMTIE.csv

4.7 TDEV versus Time

The *TDEV vs Time* data file must have a CSV format with minimum two columns:

1. The first column must contain time data (s)
2. The second column must contain summary TDEV (ns)
3. All subsequent columns can contain TDEV (ns) for selected contributors (if simulation is enabled):
 - a. Temperature
 - b. Clock Wander
 - c. Daily Aging

The first row of the file contains column labels.

Time (s)	Total Time Error (ns)	Time Error due to Temperature (ns)	Time Error due to Drift (ns)
0.1	0.003025	0.004845	1.74E-08
0.3	0.012611	0.043599	1.56E-07
0.5	0.032312	0.121001	4.32E-07
0.7	0.061951	0.236786	8.43E-07
1	0.124052	0.48145	1.71E-06
1.1	0.14927	0.581627	2.07E-06
1.3	0.206231	0.809323	2.87E-06
1.5	0.271585	1.07267	3.81E-06

1.8	0.384614	1.532017	5.46E-06
2	0.469633	1.879172	6.71E-06
2.5	0.714546	2.879026	1.04E-05
3	1.002141	4.045951	1.48E-05
...

The file name will have simulation type and data type attached to its base defined by user. For example:

TimeErrorSimulationTestPTPOnlyLockStateSimTDEV.csv

4.8 Plots

All plots are saved in PNG format. The SW will save summary plots as well as plots by each selected contributor for each simulated system parameter (if simulation is enabled). The file name will have simulation type, data type and contributor short name attached to its base defined by user. For example:

TimeErrorSimulationTestPTPOnlyLockStateSimTDEV.png

Appendix A. Examples

The following illustrates some example screenshots of simulation completion. Please refer to Figures 19-20.

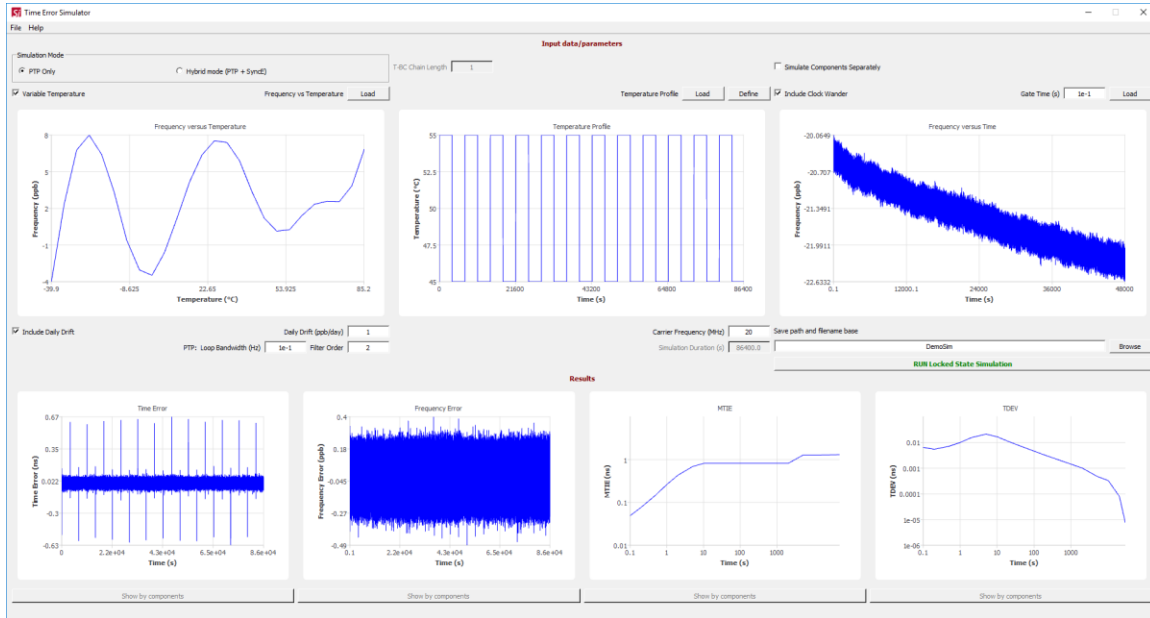


Figure 19: PTP Only Mode simulation example

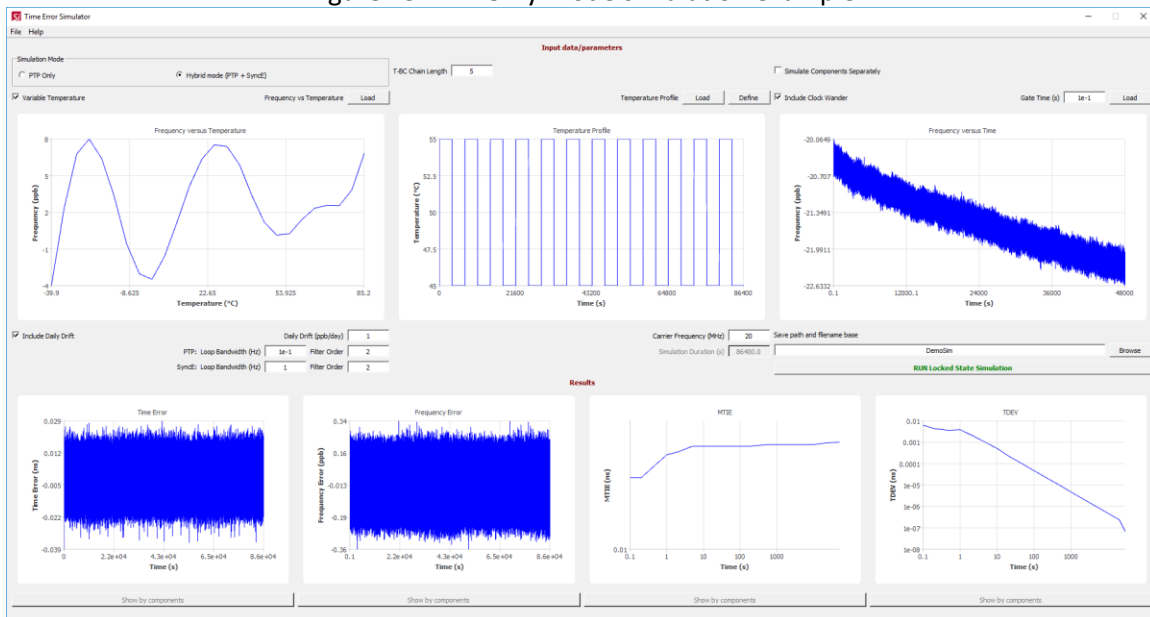


Figure 20: Hybrid Mode simulation example. 5 T-BC chain

Table 2. Revision History

Version	Release Date	Change Summary
1.0	10/10/2019	Initial release

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