Stable32 Version 1.62 User Manual Addendum

This document describes the user interface changes in Version 1.62 of the Stable32 program for frequency stability analysis that are not included in Version 1.54 of the Stable32 User Manual of 09/07/2008. Version 1.62 of Stable32 is freely distributed by the IEEE UFFC-S and is no longer available from or supported by Hamilton Technical Services.

● **Function Keys**

One additional function key command was added to the Stable32 user interface. The Shift F2 key now provides immediate access to NIST Special Publication SP1065, the *Handbook of Frequency Stability Analysis*.

Key	F1	F2	F3	F4		F5	F6	F7	F8		F9	F10	F11	F12
Normal	Help	File #1	File #2	File #3		Conv	Edit	Plot	Stats		Run	Power	ACF	Select
Shift	Manual	Handbook												

● **File Header Items**

Several additional data file header items are now supported:

File Header Item	Stable32 Style	UNIX Style	Remarks
Data addend	`Addend: value`	`# Addend= value`	*value* is added to each datum.
Data multiplier	`Multiplier: value`	`# Multiplier= value`	Each datum is multiplied by *value*.
Timetag scale	`Tag Scale: value`	`# Tag Scale= value`	The timetags are multiplied by *value*.
Timetag offset	`Tag Offset: value`	`# Tag Offset= value`	*value* is added to each timetag.
Header end flag	–	`# Header End`	Terminates file header reading.

These header file items are the same as those of the Inputs function, and replace the previous Inputs values. The file header items must use the exact syntax shown. They may be anywhere in the file, but are generally placed at the top. The header end flag is optional and can be used to speed up data file reading by terminating the search for more header items. *Value* is the numeric value of the parameter. Spaces between the : or = and the value are optional.

In addition, there are four new UNIX-style data file header items that can be used in pairs to control the data file reading process as shown in the table below:

File Header Type	File Header Item	Format	Remarks
Data size and number of columns.	# data points	`# Size=value`	*value* is # of data points to be read.
	# data columns	`# Cols=value`	*value* is # of data columns.
Data file column usage.	Timetag column #	`# TagCol=value`	*value* is 1-based column # of timetags.
	Data column #	`# DatCol=value`	*value* is 1-based column # of data.

These optional header file items should be used in pairs. Including the size and # column values will speed up the data reading process slightly, and the size can be used to truncate the data set. Including the column #s will eliminate the need for their manual entry in the Multicolumn dialog box. If used, the `# TagCol=` and `# DatCol=` header items must precede the `$ Size=` and `# Cols=` items.

Both # and ; may be used to start a comment line.

● **Cross-Correlation Allan Deviation**

Calculation of the cross-correlation Allan Deviation, #ADEV, is now supported. Two phase data files having the same number of points representing data from simultaneous measurements using two separate measuring systems whose noise will be cancelled by the cross-correlation process are read into Stable32 and stored in the first two phase data tabs. The cross sigma is selected as the variance type in the Stable32 Run function, and is calculated from those two data sets according to the method described by A. Lepek and F.L. Walls, "Cross Correlation Analysis Improves Time Domain Measurements", *Proc. 1993 IEEE Freq. Ctrl. Symp*., pp.312-320. Cross sigma is calculated exactly like the normal overlapping Allan deviation except that the products of separate x[] array values are used instead of the square of values from a single array. The resulting sigma can have either sign (not shown).

An example of a #ADEV calculation is shown below. Figure 1 shows the ordinary overlapping ADEV for one of the two data sets and Figure 2 shows the corresponding cross-correlation ADEV. These data from a coherent test produced a 1-second #ADEV of about 6.0×10^{-15} compared with an individual 1-second stability of about 6.5×10^{-14}. The cross-correlation technique thus improved the measuring system noise floor by a factor of about x10.
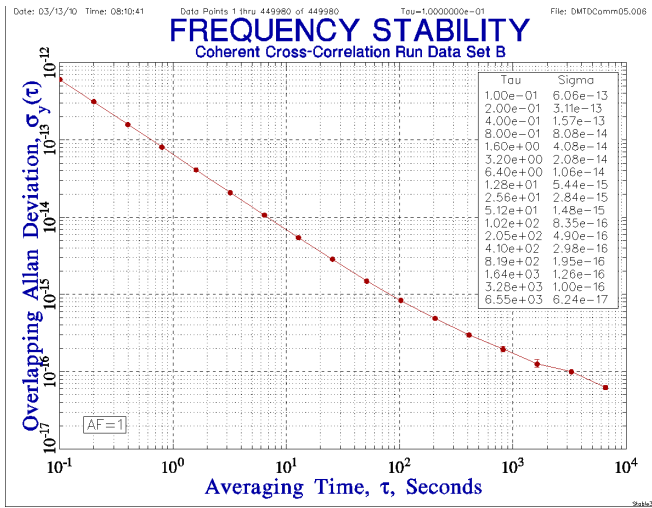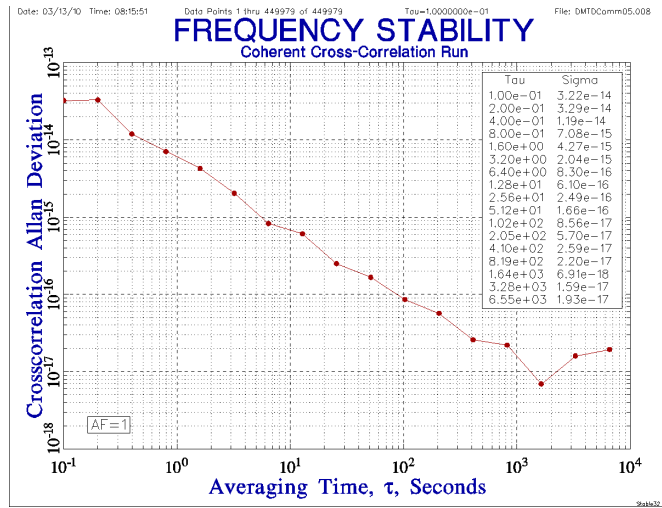
FREQUENCY STABILITY
Coherent Cross-Correlation Run Data Set B

Tau	Sigma
1.00e−01	6.06e−13
2.00e−01	3.11e−13
4.00e−01	1.57e−13
8.00e−01	8.08e−14
1.60e+00	4.08e−14
3.20e+00	2.08e−14
6.40e+00	1.06e−14
1.28e+01	5.44e−15
2.56e+01	2.84e−15
5.12e+01	1.48e−15
1.02e+02	8.35e−16
2.05e+02	4.90e−16
4.10e+02	2.98e−16
8.19e+02	1.95e−16
1.64e+03	1.26e−16
3.28e+03	1.00e−16
6.55e+03	6.24e−17

AF=1

Overlapping Allan Deviation, $\sigma_y(\tau)$ vs Averaging Time, τ, Seconds

Figure 1. Frequency Stability

FREQUENCY STABILITY
Coherent Cross-Correlation Run

Tau	Sigma
1.00e−01	3.22e−14
2.00e−01	3.29e−14
4.00e−01	1.19e−14
8.00e−01	7.08e−15
1.60e+00	4.27e−15
3.20e+00	2.04e−15
6.40e+00	8.30e−16
1.28e+01	6.10e−16
2.56e+01	2.49e−16
5.12e+01	1.66e−16
1.02e+02	8.56e−17
2.05e+02	5.70e−17
4.10e+02	2.59e−17
8.19e+02	2.20e−17
1.64e+03	6.91e−18
3.28e+03	1.59e−17
6.55e+03	1.93e−17

AF=1

Crosscorrelation Allan Deviation vs Averaging Time, τ, Seconds

Figure 2. Cross-Correlation Frequency Stability

● **Enhanced Histogram Plot Controls**

The Histogram Plot dialog box has been enhanced by adding controls to select the # of bins, to scale the data, and to adjust the x and y-axis labels and plot scales, as shown in Figure 3. The new controls are as follows:

| Group	Control	Description
Bins	# Bins	Enter # histogram bins
	Bin Size	Show histogram bin size
Data	Avg	Show data average
Scaling	Offset	Scale data by offset
	Multiplier	Scale data by multiplier
X-Axis	Label	Enter x-axis label
	Data Max	Show maximum data value
	Scale Max	Enter maximum scale value
	Data Min	Show minimum data value
	Scale Min	Enter minimum scale value
	Scale Step	Enter scale step value
X-Axis	Label	Enter y-axis label
	Data Max	Show maximum histo frequency
	Scale Max	Show maximum data value
	Data Min	Show minimum histo frequency
	Scale Min	Enter minimum scale value
	Scale Step	Enter scale step value
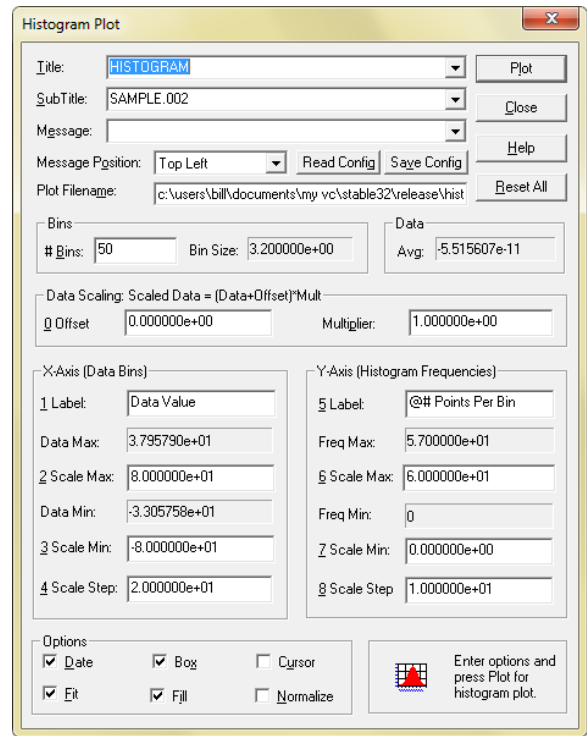
Figure 3. Enhanced Histogram Plot Dialog Box

In addition, a Histo.dat file is automatically written with the histogram data each time a histogram plot is drawn.

● **Plot Inserts Dialog Box**

The Plot Inserts dialog box controls the insertion of sub-plots into the lower left of phase, frequency, stability or autocorrelation plots. For example, a sub-plot showing the frequency data can be inserted into a stability plot as shown in Figure 4. These sub-plots must be generated as GraphiC *.TKF files before they can be included into another plot. They have the default filenames p_insert.tkf, f_insert.tkf, s_insert.tkf and a_insert.tkf for phase, frequency, stability and autocorrelation plots respectively. Do not insert the same plot into itself. When activated, it will be inserted into the corresponding plot. This feature is especially useful when preparing a stability plot for publication, or when used in a batch script to automatically document a stability analysis. The controls associated with the Plot Inserts dialog box are shown in Figures 5 and 6.
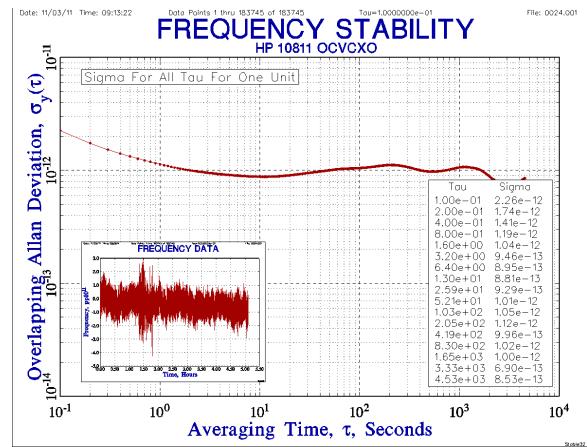
Figure 4. Example of Plot Insert

| Group	Control	Description
Plot Type	Label	Phase, Freq, Stability or ACF
Activate	Checkbox	Activate plot insert
Filename	Edit	Enter plot insert filename
Browse	Pushbutton	Choose plot insert file
Default	Pushbutton	Default plot insert file
Clear	Pushbutton	Clear plot insert file
Help	Pushbutton	Invoke Plot Inserts help file
OK	Pushbutton	Close Plot Inserts dialog box

Figure 5.
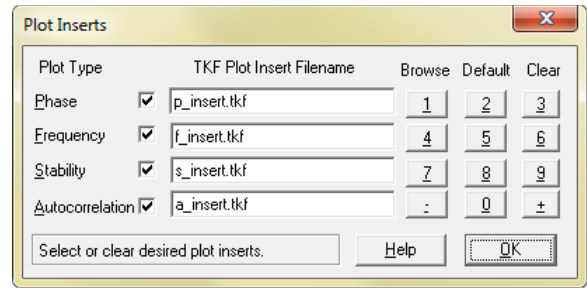
Figure 6. Inserts Dialog Box

● **Frequency Offset Phase Plot Line Option**

A **Freq Offset** option was added to the Phase Plot Lines function to display a linear fit to the phase data plot to show the average frequency offset.

● **All Tau Stability Plot Table**

An optional sigma-tau table was added to all tau stability plots, controlled by the **Table** check box and **Table Position** list box in the Run Plot Options function.

● **Phase Step Removal Function**

A new **Unstep** phase step removal function was added to the Edit menu whose purpose is to remove sawtooth phase steps that result from measurement system spillovers (e.g., 100 ns steps for a 10 MHz carrier having a relatively large frequency offset). The **Unstep** dialog box is shown in Figure 7. The number of phase steps is displayed along with their estimated span, which can be edited to an exact known value. Gaps can be inserted into the data at the steps to avoid discontinuities. The unstep operation is then performed with OK or aborted with Cancel. An example of phase data before and after sawtooth step removal is shown in Figures 8 and 9.
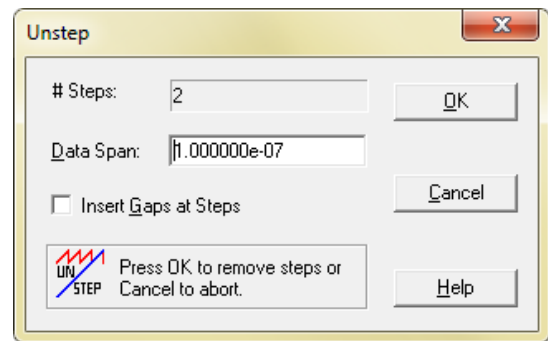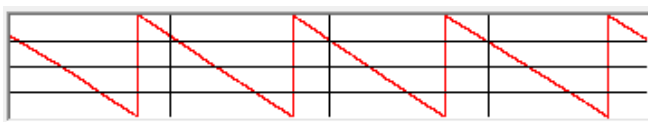

Figure 7. Unstep Dialog Box

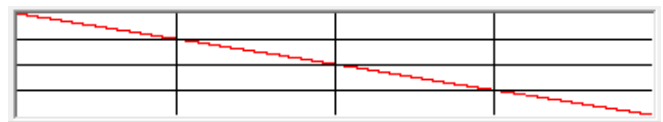Figure 8. Phase Data with Sawtooth Steps

Figure 9. Phase Data with Steps Removed

- **Greenhall Drift Estimator**

The Greenhall drift estimator was added to the choices for calculating frequency drift from phase data in the Drift function. This method is applicable to all noise types.

- **Command Line Commands**

A set of –X command line commands was added to automate the Stable32 program as shown in Figure 10, as well as a new -? command to display that help information.

The –X commands may be used along with the data file opening and tau setting commands to perform an analysis from within a batch file. A phase or frequency data file can be converted to the opposite type and all or a portion of it can be selected for analysis. Outliers can be removed from frequency data. Phase or frequency data may be averaged to a longer tau, and frequency drift and the mean value may be removed from it. Then the data may be plotted, or its stability, power spectrum, autocorrelation function or histogram can be calculated and plotted. Those plots can be printed or copied as metafiles to the clipboard. Then the plot and program can be closed.

While multiple printouts are supported, only one plot metafile can be retained on the clipboard. The command line commands can be issued in any order and must be separated by one or more spaces. The –XV# command takes an additional integer averaging factor parameter, the –XU# # command takes two integer start and end parameters separated by a single space, and the –XR command has one additional argument to set the variance type.

These new –X functions can be issued in either upper or lower case, and are complementary to the original Stable32 –O Auto# automation script functionality.
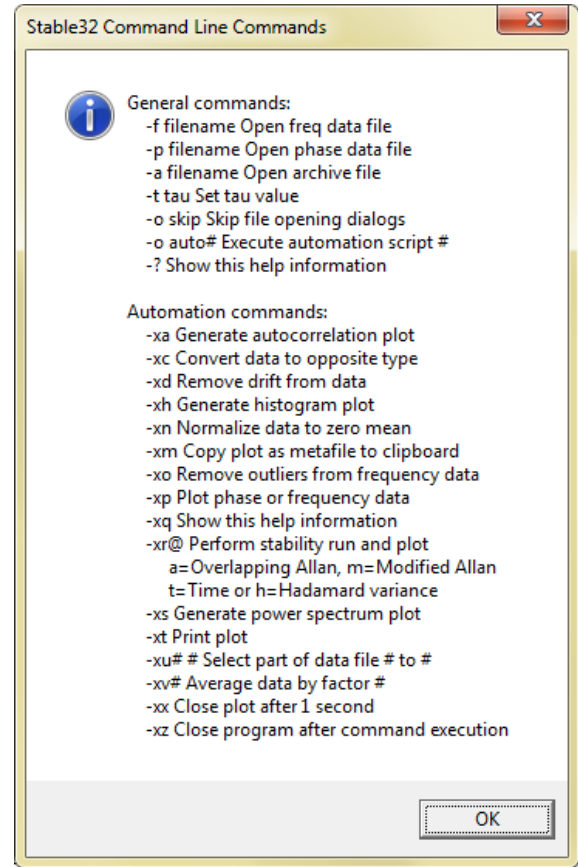

Figure 10. Stable32 Command Line Commands

- **Plot Style Option**

Version 1.59 of Stable32 includes a new plot style option in the Plots tab of the Configure box (see Figure 12). The Original style is fine on-screen and for large printouts, but the axis labels can be hard to read in a small size or when projected in a large room. The Modern style uses a simpler font for the axis labels, which are larger and have upright y-axis numbers as shown in Figure 11. When the Modern style is selected, several plot options are set for a cleaner plot, but they may be changed by the user.
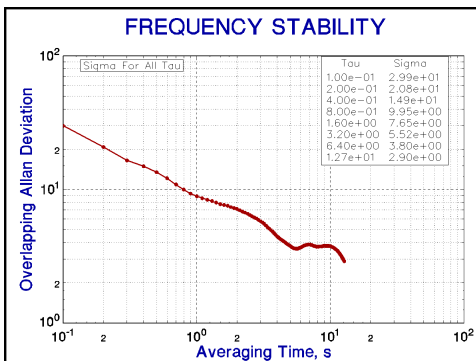

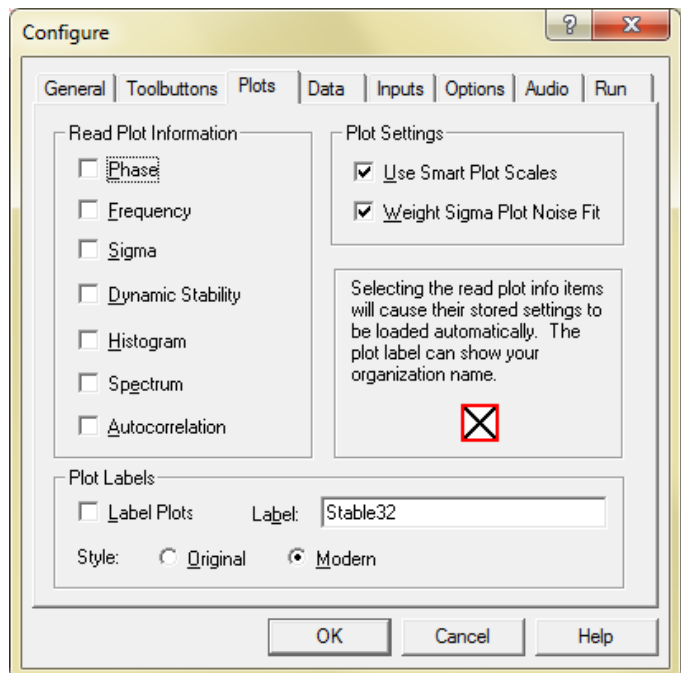Figure 11. Modern-Style Stability Plot

Figure 12. Plots Tab of Configure Dialog Box

- **Stats Function Delete Button**

An **X** button was added to the Stats function to delete the selected phase or frequency data point. When pressed, a message box is displayed to confirm the delete operation. If accepted with OK, the selected data point is replaced with a gap (zero). Because zero is considered a valid value for the first or last phase data point, the Edit function must be used to remove those points. The delete operation is intended mainly as a convenient way to remove a small number of phase outliers. It cannot be undone unless the original data is first saved in a data tab. The Check function is the recommended way to remove outliers from frequency data.

- **Integrated Phase Jitter and Residual FM**

Values for the integrated phase jitter in both radians rms and picoseconds rms, and values for the residual FM in Hz rms were added to the Domain function. Those noise parameters are calculated for the same start and end sideband frequency range as for the PSD plot.

- **3-Cornered Hat Error Bars**

Error bars are now supported for 3-cornered hat stability results when some of them have negative variances. They still require positive variances for all three units at a certain tau.

- **Miscellaneous Changes and Corrections**

1. The Normalize function opens automatically when needed for a phase or frequency data plot.
2. An error in the dynamic stability plotting function was corrected.
3. An error in setting the ThêoH error bars for divergent data was corrected.
4. An error in reading data files with a # Header End entry was corrected.
5. The .txt and .csv extensions were added to the list of data filename choices.
6. The first UNIX-style file header is copied into the plot subtitle string array.
7. Note that a CTRL-M keystroke will copy a Stable32 GraphiC plot to the Windows clipboard as a metafile.
8. A help filename edit control was added to the Filenames dialog box.
9. The help file calls were changed to use the full path.
10. Added display of max data file size limit in Too Large dialog box.
11. Added Clear All button to Clear dialog.
12. An Outliers.dat file is written each time the Check function is executed.
13. A RunIncrement item was added to the [Preferences] section of the Stable32.ini file to save, recall and set the Decade/Octave/AllTau settings for the Run function, with respective values of 0, 1 and 2.
14. All references to Hamilton Technical Services are to be ignored.