

TSC 5120A and 5115A

Phase Noise Test Set

Operations and Maintenance
Manual

For Software Revision 254



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5120A and 5115A Phase Noise Test Set Operations and Maintenance Manual

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DOC05120A Rev G

Revision History:

Revision	Description	Date	Approved
A	Initial Release	12/20/2004	GAR
B	Updates for new software features.	1/13/2005	GAR
C	Updates for hardware and software changes	3/25/2005	GAR
D	Updates for software changes	9/26/2005	MSS
E	Documents 5115A. Updates for software changes.	12/19/2005	PKS
F	Software changes, noise floor specs, and DOCSIS.	01/19/2006	GAR
G	Frequency counter precision and spur detection.	05/16/2006	GAR

Contents

1: Introduction	1
1.1 Symbols	1
1.2 About This Manual	2
1.2.1 Conventions	2
1.3 TSC 5120A and 5115A Overview	4
2: Setting Up the TSC 5120A or 5115A	7
2.1 Safety Information	7
2.2 Setting Up the TSC 5120A or 5115A	7
2.2.1 Turning On the 5120A or 5115A	9
3: The Screen and Basic Concepts	11
3.1 Softkey Interface	12
3.1.1 Navigation	12
3.1.2 Manual Convention for Navigation Instructions	13
3.2 Main Screen Components	13
3.2.1 Collecting State	13
3.2.2 Input Signals' Frequency and Power	13
3.2.3 User in Control	14
3.2.4 User Specified Title	14
3.3 Types of Screens	15
3.3.1 Plots	15
3.3.2 Tables	15
3.3.3 Configuration Screens	15
3.4 Parameters, Input Components and Editors	16
3.4.1 Numeric Parameters	16
3.4.1.1 The Number Pad Editor	17
3.4.1.2 The + and - Integer Parameter Interface	18
3.4.2 Mutually Exclusive Options	18
4: Global System Settings	21
4.1 The Settings Screen	21
4.1.1 Setting Date and Time	22
4.1.2 Network Configuration	23
4.1.2.1 Static Network Configuration	24
4.1.2.2 DHCP Network Configuration	25
4.1.3 Printer Configuration	26
4.1.3.1 Printing to a USB Printer	26
4.1.3.2 Printing to Files	27
4.1.3.3 Configuring Network Printers	28
4.1.4 Viewing Version Information	28
4.1.5 Restoring Factory Default Settings	28

5: Configuring the Data Sets	29
5.1 Configuring Phase Noise Data	29
5.1.1 Scaling the Phase Noise Plot	30
5.1.2 Setting Data Markers	32
5.1.3 Setting Up a Test Mask	35
5.1.4 Display Tools	38
5.1.5 The Spur Table	38
5.2 Configuring the Allan Deviation Plot	40
5.2.1 Scaling the Allan Deviation Plot	40
5.2.2 Selecting τ_0	41
5.2.3 Viewing the Allan Deviation Table	41
5.2.4 Setting Up Allan Deviation Test Masks	41
5.3 Configuring the Phase Difference Plot	42
5.3.1 Scaling the Phase Difference Plot	42
5.3.2 Removing the Linear Trend	43
5.3.3 Pausing or Resuming Updates	45
5.4 Configuring the Frequency Difference Plot	46
5.4.1 Scaling the Frequency Difference Plot	46
5.4.2 Pausing or Resuming Updates	46
5.5 Configuring the Frequency Counter	47
5.5.1 Changing the Reference Frequency	48
5.5.1.1 Automatically Setting the Reference Frequency	48
5.5.1.2 Manually Setting the Reference Frequency	49
6: Collecting and Viewing Data Locally	51
6.1 Starting and Stopping Data Collection	51
6.2 Printing	52
6.3 Taking or Yielding Local Control	53
7: Collecting and Viewing Data Remotely	55
7.1 Accessing the 5120A or 5115A Remotely and Exiting the Remote Session	56
7.2 The Network Command Port	57
7.2.1 Taking or Yielding Remote Control	57
7.2.2 Starting and Stopping Data Collection	57
7.2.3 Retrieving Data from Command Port	58
7.2.4 Printing from the Command Port	59
7.2.5 Printer Configuration from the Command Port	60
7.2.6 Configuring Data Sets from the Command Port	60
7.2.6.1 Pausing and Resuming Phase and Frequency Difference	60
7.2.6.2 Removing the Linear Trend	60
7.2.6.3 Setting the Allan Deviation τ_0 Value	61
7.2.6.4 Setting Frequency Counter's Reference Frequency	61
7.2.7 Retrieving Status Information	62

7.2.8 Setting the User Specified Title	62
7.2.9 Showing the Software Version	62
7.2.10 Viewing Help for Remote Commands	63
7.2.11 Other Commands	63
7.2.12 Command Summary	64
7.3 The Network Data Port	66
8: Optional Functionality	67
8.1 DOCSIS	67
8.1.1 DOCSIS Overview	67
8.1.2 Using the DOCSIS Option Locally	68
8.1.3 Using the DOCSIS Option Remotely	69
9: Maintaining the TSC 5120A or 5115A	71
9.1 Calibrating the 5120A or 5115A	71
9.2 Cleaning the 5120A or 5115A	71
10: Troubleshooting the 5120A or 5115A	73
10.1 Troubleshooting Error Messages	74
10.2 Replacing Fuses	76
Appendix A: Specifications	77
A.1 EC Declaration of Conformity	77
A.2 Electrical Specifications	78
A.3 Environmental Specifications	80
A.4 Physical Specifications	81
Appendix B: Theory of Operation	83
B.1 Introduction	83
B.2 Theory	84
B.3 Measurement Methodology	88
Glossary	89
Index	91

1: Introduction










Note

FIRST READ THIS MANUAL THOROUGHLY!

This is especially true for the sections regarding **Safety** and **Setup**.

1.1 Symbols

These symbols appear throughout the manual and on the TSC 5120A or 5115A.

Symbol	Definition
 Note	This symbol means the following information is a note that gives you important information that may affect how you use the 5120A or 5115A.
	Caution, refer to manual. Read all instructions in this manual before using this product.
	Caution - Risk of Electrical shock
	Fuse symbol.
	LAN port, network. DO NOT CONNECT TO TELECOM CONNECTIONS THAT CARRY HAZARDOUS VOLTAGES.
	Universal Serial Bus (USB) port.
	Mains power on and off. Mains power is on when the button is in the depressed position and off when the button is in the out position.

1.2 About This Manual

This manual describes how to set up, use, maintain, and troubleshoot a TSC 5120A or 5115A.

“[Chapter 1, Introduction](#)” on page 1 explains symbols that appear in the manual and on the unit as well as documentation conventions. The chapter also briefly describes the test set.

“[Chapter 2, Setting Up the TSC 5120A or 5115A](#)” on page 7 contains important safety information and describes how to set up the test set for the first time.

“[Chapter 3, The Screen and Basic Concepts](#)” on page 11 describes the main components of the graphical user interface, basic concepts related to navigating the user interface, and making settings in general.

“[Chapter 4, Global System Settings](#)” on page 21 describes individual system settings such as system time, network configuration and printer settings in detail.

“[Chapter 5, Configuring the Data Sets](#)” on page 29 describes the various data sets the 5120A and 5115A provide and how to manipulate and configure each data set.

“[Chapter 6, Collecting and Viewing Data Locally](#)” on page 51 describes how to start and stop data collection and how to print using the front panel.

“[Chapter 7, Collecting and Viewing Data Remotely](#)” on page 55 describes how to view, print and configure data sets using the Ethernet command port.

“[Chapter 8, Optional Functionality](#)” on page 67 describes optional functionality.

“[Chapter 9, Maintaining the TSC 5120A or 5115A](#)” on page 71 describes how to maintain the test set.

“[Chapter 10, Troubleshooting the 5120A or 5115A](#)” on page 73 describes how to troubleshoot error messages.

“[Appendix A, Specifications](#)” on page 77 contains the detailed specifications for the test set.

“[Appendix B, Theory of Operation](#)” on page 83 contains the detailed information about the algorithms and underlying theories for the test set.

1.2.1 Conventions

This manual uses several typographical conventions to help explain how to use the TSC 5120A or 5115A.

Convention	Definition
Bold	Words in bold show: <ul style="list-style-type: none"> ■ Buttons and icons to click ■ Menu options to select ■ Commands to type ■ Non-variable information displayed in response to commands
<i>Italics</i>	Words in <i>italics</i> show: <ul style="list-style-type: none"> ■ Names of windows and dialog boxes ■ Variable information displayed in response to commands ■ State information, label and button captions

1.3 TSC 5120A and 5115A Overview

The TSC 5120A and 5115A are instruments that combine sophisticated timing technologies into a single advanced test set for the measurement of $\mathcal{L}(f)$ phase noise. The low-noise, bench-top instrument combines the latest digital synthesizer, active mixer, and dual conversion techniques to capture precise, accurate $\mathcal{L}(f)$ phase noise measurements. The TSC 5120A also performs cross-correlation of the digitized signal from both input paths to provide the lowest possible noise floor measurement.

The 5120A and 5115A are designed for ease of use. Little configuration is required. Just connect two signal sources to the BNC (using supplied adapters) inputs and press **Start**.

The input impedance is 50Ω , and the nominal input level ideally should be near $1 V_{RMS}$. The unit initializes itself, measures the frequencies of the input signals, configures the signal paths, and collects data.

You have a choice of five primary plot displays: phase noise, Allan deviation, frequency counter, frequency difference, and phase difference.

An Ethernet port on the rear panel provides the capability to remotely control the instrument. Two USB ports on the rear panel provide connections for a printer, mouse and keyboard.

Figure 1 shows the test set's front panel, and Figure 2 shows the test set's rear panel.

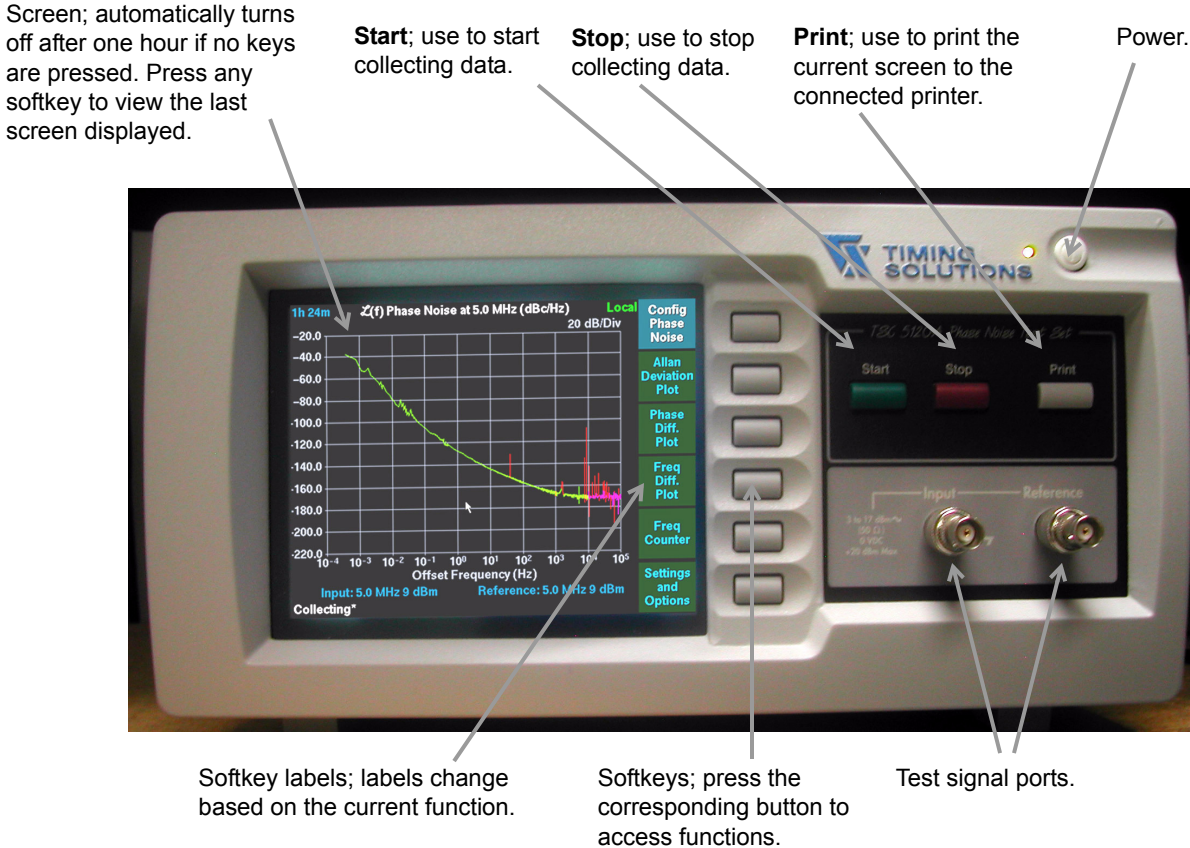


Figure 1: Front panel

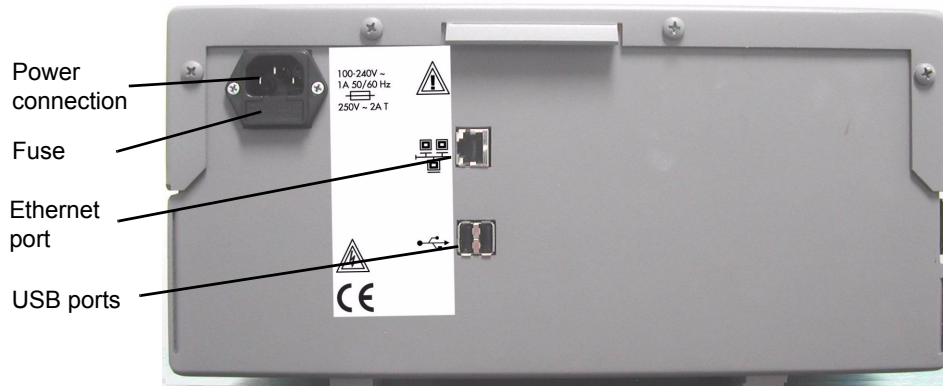


Figure 2: Rear panel

All measurements are made between the Input and Reference ports. A clean and stable signal must be supplied to the Reference port in order to ensure that the measured characteristics are those of the Input signal.

The phase noise and phase spurs that are present on the Reference port are scaled by a factor of $20 \cdot \log (F_{in}/F_{ref})$ when displayed. Consider the following example: A spur on a 10 MHz signal is connected to the Input port with a clean 5 MHz connected to the Reference port. The spur reading is -50 dBc. If the input cables are swapped between the ports, the spur reading will be -56dBc."

2: Setting Up the TSC 5120A or 5115A

You should read the safety information below before setting up the test set. For more information,

see the following:

- “2.2 Setting Up the TSC 5120A or 5115A” on page 7
- “3: The Screen and Basic Concepts” on page 11
- “4.1.1 Setting Date and Time” on page 22
- “4.1.2 Network Configuration” on page 23
- “4.1.4 Viewing Version Information” on page 28

2.1 Safety Information



Warning

This unit is for indoor use only. It is not sealed to prevent moisture from entering the enclosure.

Do not set up or operate this equipment if you have not first received proper training.

Ensure that all cables are properly connected. The power cord must be located for easy removal.

Verify that input line voltage and current capacity from the supply circuit are within specifications before turning on power to the test set.

Operating and maintenance personnel must receive proper training before setting up or maintaining electrical equipment.

2.2 Setting Up the TSC 5120A or 5115A

The test set ships ready to set up on a desk, table, or other stable, flat surface.

Required for setup:

- North American or European IEC power cord. One or the other will be supplied with the instrument.
- Two TNC male to BNC female adapters are supplied with the instrument.
- Two customer-supplied 0.5-meter (approximately 19") coaxial cables terminated at one end with male BNC connectors. The other end should have the appropriate connector as determined by your application.

Optional components:

- Customer-supplied USB A-type cables, one for each USB device.
- Customer-supplied USB mouse. (recommended)
- Customer-supplied USB keyboard.
- Customer-supplied USB hub, if connecting more than two USB devices.
- Customer-supplied USB printer from the list of compatible printers.
- Customer-supplied CAT 5 LAN cable for network connection (RJ-45), if connecting to the Ethernet port.
 - If you need to connect the test set directly to your computer using the Ethernet port, you must use a crossover cable instead of a standard LAN cable.

To set up the 5120A or 5115A:

1. Carefully unpack and inspect the test set.
2. Check for physical damage.
 - If you observe physical damage, immediately contact Timing Solutions and the carrier. We recommend saving the shipping container for submitting any necessary claims to the carrier.
3. Verify that the front panel power button is turned off.
4. Plug the female end of the power cord into the male IEC-320 plug on the rear of the test set.
5. Plug the male end of the power cord into a 100–240 V AC, 50/60 Hz power source.



Caution

Ensure that this power supply cord is connected to a properly grounded mains receptacle.

6. Connect one coaxial cable from the Device Under Test (DUT) signal source to the Input port of the test set.
7. Connect another coaxial cable between the signal reference and the Reference input port of the test set.
8. (Optional.) Connect a CAT 5 LAN cable to the Ethernet port on the rear panel of the test set.
 - For information about configuring the network connection, see [“4.1.2 Network Configuration”](#) on page 23.
9. (Optional.) Connect the USB A-type cables from a mouse, keyboard or printer to the USB ports on the test set.
 - If you are connecting more than two USB devices, connect a USB hub to one port on the test set, then connect the devices to the hub.
 - You can also use a USB-to-parallel adapter for a parallel-port printer.

You are now ready to turn the test set on.

2.2.1 Turning On the 5120A or 5115A

Once you have set up the test set, you are ready to turn it on.

To turn on the test set:

- Press the **Power** button on the front panel.
 - The Timing Solutions logo displays.
 - The main screen displays about 1 minute later. The main screen defaults to the phase noise plot.
 - When *Ready* displays in the status field (see [Figure 3](#) on page 11 and “[3.2.1 Collecting State](#)” on page 13) the instrument is ready for normal operation.
 - If the “Self test has failed for the following item(s)...” message displays, call a TSC service representative for assistance.

Once *Ready* is displayed in the status field, data can be collected.

3: The Screen and Basic Concepts

The screen on the front panel of the TSC 5120A or 5115A displays data as plots or tables, status information, and system configuration such as network settings. It defaults to the $\mathcal{L}(f)$ phase noise data plot when the test set is powered on.

Figure 3 depicts the default screen after the test set has been collecting data for over an hour. It names and describes the major components. These are described in section “3.2 Main Screen Components” on page 13.

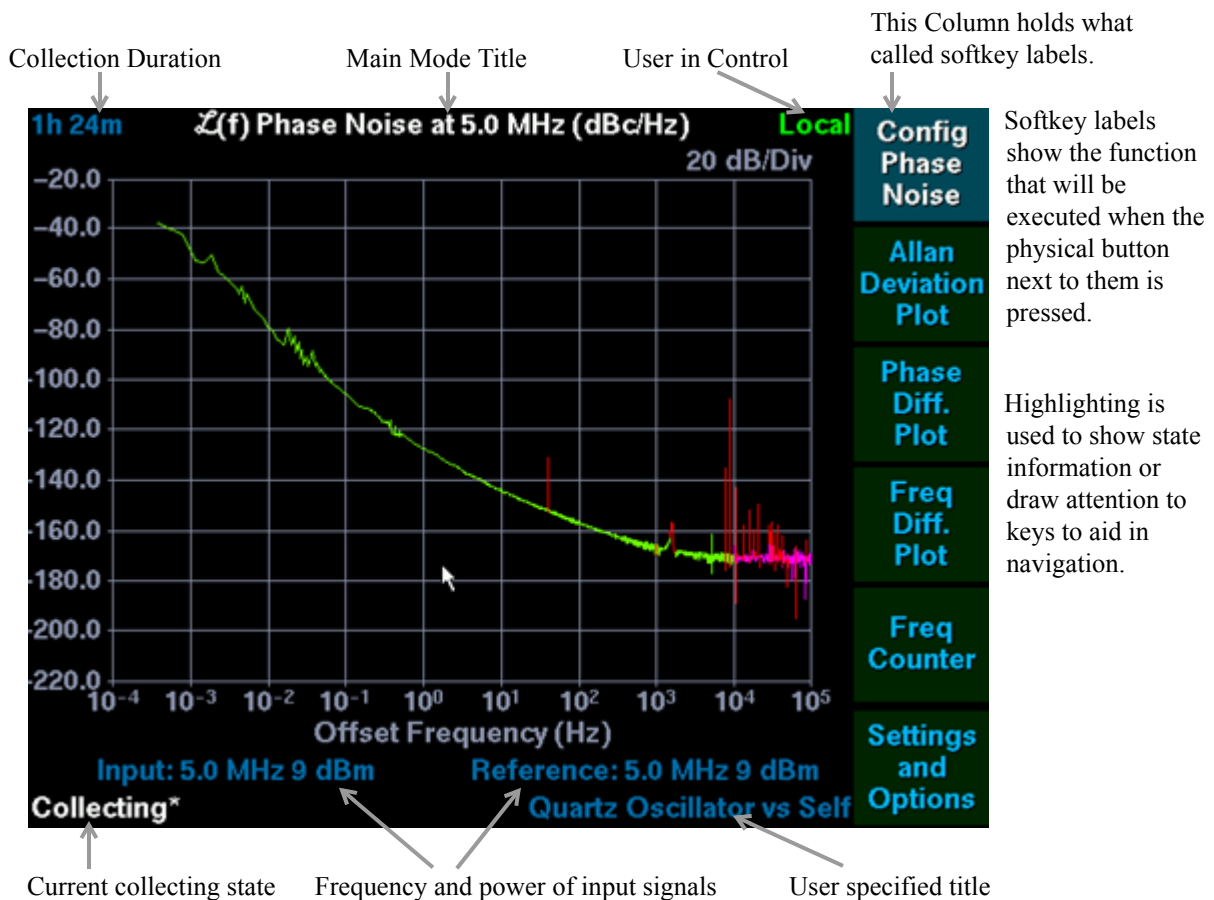


Figure 3: Default main screen

3.1 Softkey Interface

The column labeled “softkeys” in Figure 3 mirrors the set of buttons on the test set front panel (Figure 1 on page 4 shows them side by side). The labels indicate the effect pressing the corresponding button will have.

The function of a softkey changes depending on previous selections including navigation and settings. Highlighting is used to represent state information, to invite navigation into a submenu, or to return to a previous menu. The softkey interface can be used to configure all aspects (except the **User Specified Title**). It is described in detail in the sections that follow.

A USB mouse can be used to press and release softkeys. To execute the function currently assigned to a softkey, click on it. Some softkeys repeatedly execute their function while held down. These keys are noted as they are described in this manual. Pressing (and holding) the mouse button on a softkey repeatedly executes its function as well. Using the mouse to interact through the softkey interface is also useful because it minimizes physical disturbance to the test set. Physical disturbance can affect the accuracy of measurements.

3.1.1 Navigation

Starting with the phase noise plot as shown in Figure 3, pressing the **Allan Deviation Plot** button would:

- Display the Allan deviation plot
- Change the softkey’s caption to **Config Allan Deviation**
- Highlight the softkey to show that Allan deviation is the active mode

Pressing the same button at this time will enter a softkey menu (center in the figure below) that allows for scale and test mask configuration, τ_0 selection, or viewing the Allan deviation in table format. This softkey menu has a highlighted **Return** softkey to return to the previous menu.

Figure 4 shows the flow from the Allan deviation plot, to its table format, and back to the plot.

The second softkey now configures the Allan deviation plot. It was just used to select the Allan deviation plot.

The top softkey now reselects the phase noise plot. Its original function was to configure the phase noise plot.

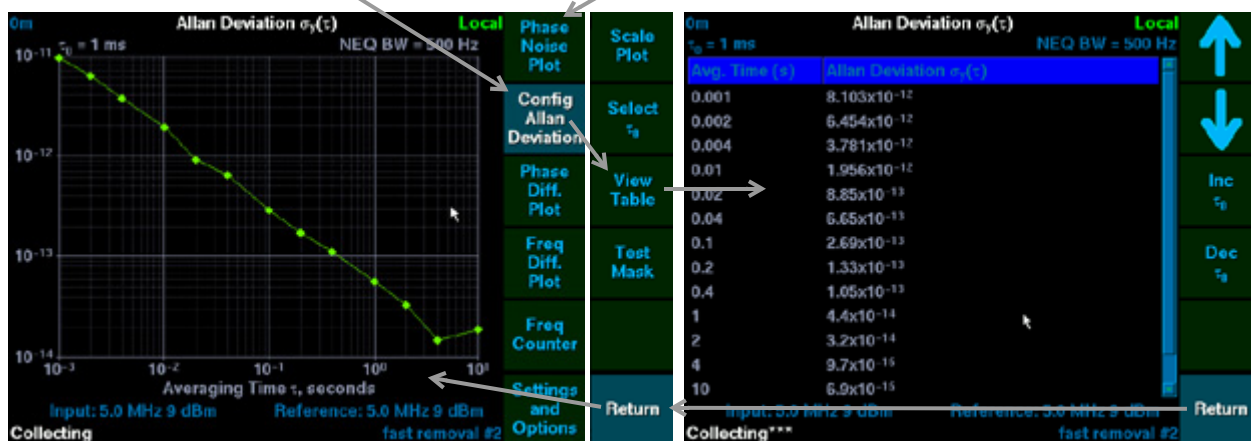


Figure 4: Softkey Navigation

3.1.2 Manual Convention for Navigation Instructions

This manual uses the following convention to describe the softkey-based navigation flow shown in [Figure 4](#) on page 12:

To view the Allan Deviation Table:

1. From the Allan deviation plot, press **Config Allan Deviation**.
2. Press **View Table**.
3. Press **Return** to go the previous screens.

3.2 Main Screen Components

This section provides a description of the main screen components shown in [Figure 3](#) on page 11.

3.2.1 Collecting State

The collecting state shows the test set's current mode of operation. The test set is in one of three states at any given time: *Ready*, *Initializing* or *Collecting*.

- In *Ready* state you may **Start** collecting provided that the Input and Reference signals' frequency and amplitude are within operating range.
- The *Initializing* state is a transition from *Ready* to *Collecting* state. In the *Initializing* state, the test set takes a small set of measurements and uses it initialize the internal spur detection algorithm. The *Initializing* state lasts up to 30 seconds.
- *Collecting* state is entered once initialization is complete and the test set has begun collecting and presenting data. When *Collecting* state is reached the test set starts displaying measurements and tracking how long it has been collecting. See the top left corner of [Figure 3](#) for an example of the collection duration.

You can **Stop** collecting from either the *Initializing* or the *Collecting* state.

Note that updates to some data sets can be paused. The normal banner of asterisks displayed next to the collecting state will change to *Paused* to indicate that the test set is presenting a paused data set. The test set continues to make measurements and will present the most recent plot or table when updates are resumed.

All measurements and calculations made in the *Collecting* state can be viewed, printed and accessed on the network port even after you **Stop** collecting. They are cleared when data collection is restarted.

3.2.2 Input Signals' Frequency and Power

These fields display the input ports' frequency and power as measured by the TSC 5120A or 5115A. As frequency and/or power fall outside of specification or operating range the color coding of the fields changes as well. Frequency or power values displayed in red are outside of operating range. Values displayed in orange are out of specification but fall within operating range.

The screen always shows the currently connected signals' frequency and power. When a data set is printed, the frequency and power at the time the printed data set was computed is output. If data are collected with 5 MHz signals on both ports, and the reference is replaced with a 10 MHz signal, the screen shows 5 and 10 MHz, while a printout correctly shows 5 MHz for both signals.

3.2.3 User in Control

The phase noise test set can be controlled in two ways:

- with front panel buttons, a mouse and/or a keyboard
- via a network connection on an Ethernet network

This makes it possible for two different users to interfere with one another. A network user could start a long term collection, only to have another user walk up to the physical unit and press the **Stop** button minutes later. These users are named from the test set's perspective. The network user is referred to as the *Remote* user, and the person using the front panel is called the *Local* user.

To avoid interference between *Local* and *Remote* users, certain operations and configuration settings require that the user wishing to perform them be in control of the unit (or willing to take control). The user who is in control of the unit is identified in the top right corner of [Figure 3](#). The figure shows that *Local* user has initiated data collection. If a *Remote* user were to issue the stop command, they would receive a warning reminding them that they are not in control of the test set. At this point the remote user can take control from the local user. See [“7.2.1 Taking or Yielding Remote Control”](#) on page 57 for details on taking *Remote* control.

When the unit is powered on neither user is in control. The first user to execute a command or make a setting which requires control of the unit implicitly takes control. If the *Local* user were to press the **Start** button on the front panel, they would automatically take control of the unit. When neither user is in control the label in the top right corner of the main screen is blank.

When the user who is controlling the test set is finished, they can relinquish control to reenter the state described in the previous paragraph. See [“6.3 Taking or Yielding Local Control.”](#) on page 53 and [“7.2.1 Taking or Yielding Remote Control”](#) on page 57 for further instructions.

3.2.4 User Specified Title

A short string shown in the bottom right corner of [Figure 3](#) can be entered using a USB keyboard or set on the network interface. One title may be assigned at a time. The title appears on all printouts and can thus be used to correlate data sets, identify the owner or input signal sources. The title can be up to 34 characters long.

The title can be set by the *Local* user only if a keyboard is attached to the test set.

To set the user specified title:

1. Press the ‘T’ key on the keyboard.
2. Enter a title of up to 34 characters using the keyboard in the dialog.
3. Press the ‘Enter’ key on the keyboard, or the **Apply** softkey to commit the new title.
 - The new title appears at the bottom right of the main screen and will be output at the bottom of all future printouts.

The user specified title can also be set using a network command connection, see [“7.2.8 Setting the User Specified Title”](#) on page 62.

3.3 Types of Screens

The TSC 5120A and 5115A present three types of user interface main screens:

- Plots
- Tables
- Input Components

Occasionally it will present a dialog with informational messages, error messages or request that you take control (as described in “3.2.3 User in Control” on page 14) when you execute certain functions.

3.3.1 Plots

Figure 3 on page 11 and Figure 4 on page 12 are examples of plots. Four of the five main screens are plots. Plots can be configured in various ways described in detail in later chapters dedicated to data set configuration.

- The $\mathcal{L}(f)$ Phase Noise plot also presents data subsets such as the Spur Table and meta information such as Integrated Phase Noise in tables accessible through its configuration softkey and mouse menus.
- The Allan deviation plot can also be viewed in terms of a table.

3.3.2 Tables

There are two types of tables. The first is a read-only table such as the Allan deviation table. The second type is an interactive table. Both types present softkeys which scroll the table up or down as can be seen in the example table on the right side of Figure 4 on page 12. The scroll keys have different effects depending on the type:

- Read-only tables scroll the data set one page at a time.
- Interactive tables select the row following or preceding the currently selected row.

Interactive tables move the selection a row at a time because they allow you to operate on the selection. An example of this is the $\mathcal{L}(f)$ phase noise plot’s spur table, which lets you place a marker at the selected spur’s frequency. See “5.1.5 The Spur Table” on page 38 for details.

Note that row selection in interactive tables can be performed by clicking the mouse pointer on the row to operate on. Operations for the selected row are generally available in a popup menu accessed by right-clicking the selected row.

Also note that all tables can be scrolled with a mouse by:

- using the scroll bar on the right side of the table
- rotating the mouse wheel (if available)

3.3.3 Configuration Screens

The test set can be configured in various ways. Configuring aspects of its function involves setting parameters. Input components are used to interface with and make these settings. Components for related parameters are often grouped, as multiple parameters affect a certain function. Examples of such groups can be found in chapter “4: Global System Settings” on page 21 and its subsections.

3.4 Parameters, Input Components and Editors

This section explains the possible parameter types and cross references an example of each. The components which represent them, and how each type can be modified using the softkey interface, a mouse or a keyboard, are detailed in the section referenced by each type.

Parameters fall into these categories:

- “3.4.1 Numeric Parameters” on page 16 such as:
 - Network interface port numbers
 - The frequency counter’s user specified reference frequency
- “3.4.2 Mutually Exclusive Options” on page 18 such as:
 - Print job destination
 - TCP/IP address assignment method

3.4.1 Numeric Parameters

Numeric parameters fall into two categories:

- those confined to the integer domain
- those in the real number domain such as the frequency counter’s reference frequency and test mask points’ x and y coordinates

All numeric parameters can be set as described in “3.4.1.1 The Number Pad Editor” on page 17. Those in the integer domain can also be set as described in “3.4.1.2 The + and - Integer Parameter Interface” on page 18. Numeric parameters are presented using the following components which can be directly manipulated with the mouse or keyboard as described in Figure 5.

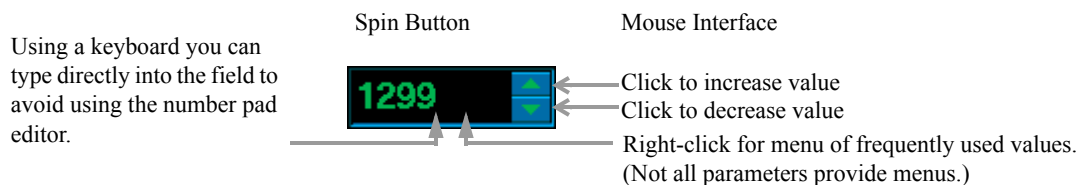


Figure 5: Spin Buttons

When a mouse or keyboard is not available, parameters presented by spin buttons must be set using one of the editors described in the following sections. The editors can be used if you prefer using them over the alternative input methods.

3.4.1.1 The Number Pad Editor

The number pad editor is a small window that resembles the number pad on a keyboard. The window's title indicates the parameter being edited (the first octet of an IP address in the figure below).

- When the number pad editor is invoked, the softkey interface changes as shown on the right side of the figure.
- If a parameter already has a value when the editor is invoked, the number pad editor is initialized with this value. Use the *Clear* button to erase the value entirely.
- The <- button (the backspace button) erases the last digit.
- The *EXP* button is used to enter numbers in scientific format.
- The +/- button toggles the sign of the mantissa when it is pushed before the *EXP* button and toggles the sign of the exponent when pushed after the *EXP* button.

Number pad buttons can be clicked with the mouse.

With a keyboard you can directly enter a value.

Note the white rectangle on the button. It indicates "focus". The arrow softkeys move the focus in the direction they indicate, wrapping to the first button on the axis on which they move focus.

Backspace erases the last digit.

Clear erases entire value.

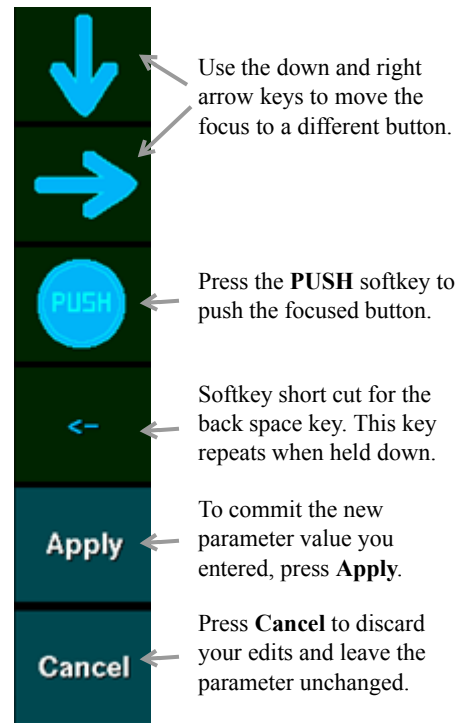
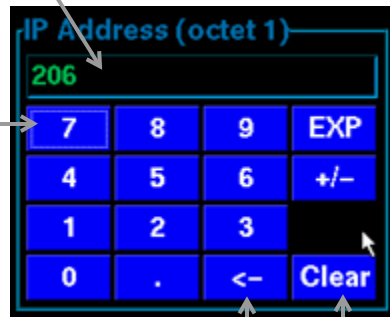


Figure 6: The Number Pad Editor

3.4.1.2 The + and - Integer Parameter Interface

Numeric parameters whose values are confined to the integer domain can be changed by incrementing and decrementing their values. They are represented by spin buttons. See “[Figure 5: Spin Buttons](#)” on page 16 for an example. When an interactive component that represents such a value is selected, the softkey interface offers both the number pad and the + and - interface as an editor:

When a spin button is selected, both [The Number Pad Editor](#) and the + and - Integer Parameter interface can be used to modify its value.

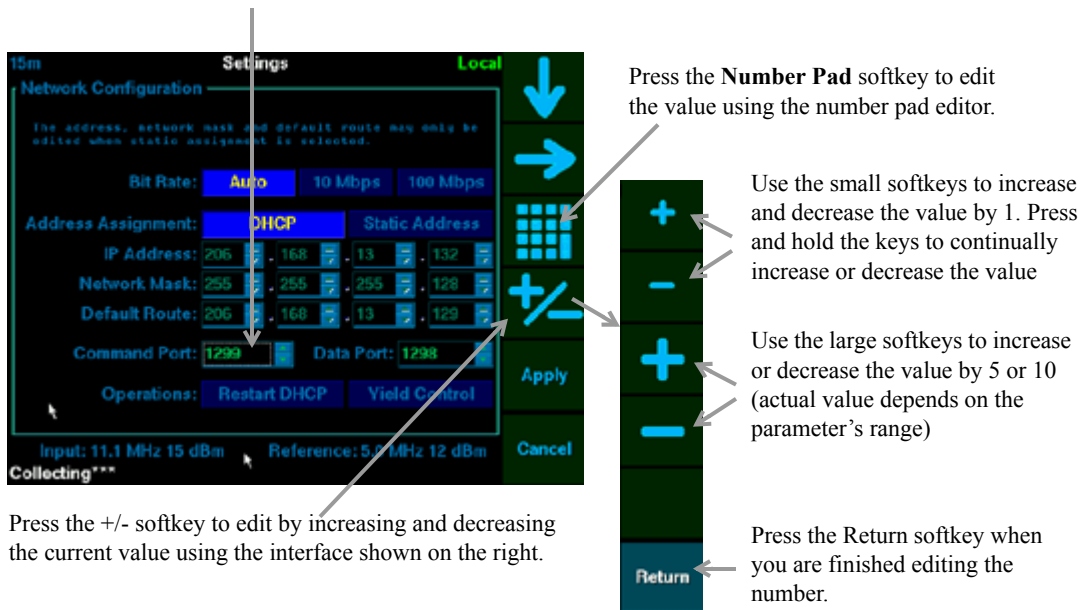


Figure 7: The + and - Integer Parameter Interface

3.4.2 Mutually Exclusive Options

Mutually exclusive options on the settings screens are presented as a horizontal row of buttons (similar to radio button controls in other graphical user interfaces). [Figure 7](#) has the following mutually exclusive options:

- *Bit Rate* which can be one of *Auto*, *10 Mbps* or *100 Mbps*
- and *Address Assignment* which can be *DHCP* or *Static Address*

The down and right arrow softkeys in [Figure 7](#) move the focus just as they do in the number pad editor. See [Figure 6](#) on page 17 for an explanation of focus. As focus is changed on mutually exclusive options the focused option is selected. The new setting takes effect when the **Apply** softkey is pressed. The following is an example of how to toggle the *Address Assignment* option assuming the state in [Figure 7](#) as a starting point.

To change the *Address Assignment* method:

1. Press the down arrow softkey until focus reaches the *DHCP* button.
 - Focus is indicated with a white rectangle.
2. Press the right arrow softkey.
 - Focus and highlight move to the *Static Address* button - the new setting.

Note that the buttons representing the options can be clicked directly with a mouse. Clicking an interactive component moves the focus - it does not have to be moved with the arrow softkeys.

4: Global System Settings

The TSC 5120A and 5115A have global configuration parameters. Many of these ship with acceptable defaults but should be checked and modified as appropriate when the unit is received. The global configuration settings persist when the test set is powered off.

Settings are grouped according to function and accessed through the Settings screen. Setting screens include:

- System date and time and time stamp format
- Network options
- Printing options

4.1 The Settings Screen

The Settings screen shows most current settings and serves as a submenu to the settings groups listed above.

To access the Settings screen:

1. Press or click the **Settings and Options** softkey.
 - See “3.1 Softkey Interface” on page 12 for basic navigation instructions.
2. Press or click the **Settings** softkey.

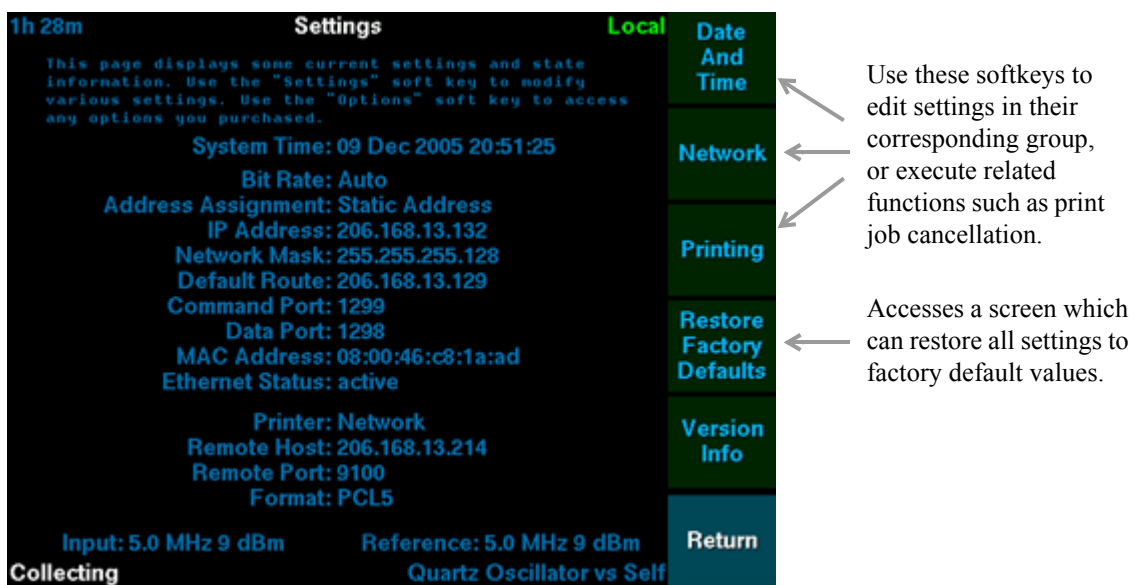


Figure 8: Settings Screen

Note that the Settings screen displays the instrument’s current IP address. Use this address to access the command and data ports, or to retrieve print jobs that were written to files.

4.1.1 Setting Date and Time

All printouts produced by the test set show the test set date and time the print job was initiated. The date and time is printed in the top left corner of the page. Date and time stamps on printouts can be used to correlate printed data sets.

To set the system date and time:

1. Press **Settings and Options**
2. Press **Settings** to access the Settings Screen (shown in [Figure 8](#) on page 21).
3. Press **Date and Time**.
4. Use the arrow softkeys to access the date/time fields you wish to modify.
5. Adjust the numeric fields as described in section “[3.4.1 Numeric Parameters](#)” on page 16.
6. Select the preferred date/time format as described in section “[3.4.2 Mutually Exclusive Options](#)” on page 18.
 - The field labeled *Sample* shows how time stamps will be printed.
7. Press **Apply** to save the new date and time and/or time stamp format.



Note

The test set does not adjust for time changes due to daylight savings time.

4.1.2 Network Configuration

In order to access the test set over a network, print to a network printer, or retrieve print jobs sent to files, network settings must be configured. Skip this section if you do not intend to use these features.

An example of the network settings screen can be found in [Figure 7, on page 18](#). It groups the following parameters:

- *Bit Rate*
 - The bit rate setting is used to force the instrument’s network controller to a given bit rate. The default of *Auto* should suffice on almost all networks. Contact a system administrator if you feel this setting must be changed.
- *Address Assignment*
 - Toggles between address assignment via Dynamic Host Configuration Protocol (*DHCP*) and a *Static Address*.
- *IP Address, Network Mask and Default Route*
 - These fields are only enabled when the *Address Assignment* is set to *Static Address*.
- *Command Port and Data Port*
 - These fields set the port numbers at which the test set will answer command line interface and data connections.

Bit Rate and *Address Assignment* are mutually exclusive options, while the octets in *IP Address* and *Network Mask*, and the *Command* and *Data Port* are all integers. See “[3.4.2 Mutually Exclusive Options](#)” on page 18 and “[3.4.1 Numeric Parameters](#)” on page 16 for details on how to set them.

The TSC 5120A and 5115A ship with the default network settings shown in [Table 1](#).

Table 1: Default network settings

Setting	Default value
Bit Rate	Auto
Address Assignment	DHCP
IP address	(set by DHCP)
Netmask	(set by DHCP)
Default Route	(set by DHCP)
Command port (TCP)	1299
Data port (TCP)	1298

If your network has a Dynamic Host Configuration Protocol (DHCP) server and the *DHCP* assignment method is selected, the IP address does not have to be configured. Once the test set is connected to the network, it should receive an IP address from the server. The address of the test set must be determined in order to make a network connection from another computer. It can be found in “[Figure 8: Settings Screen](#)” on page 21 (your system’s address will vary from that shown in the figure).

4.1.2.1 Static Network Configuration

If your network does not have a DHCP server or a static IP address is preferred, you can set an IP address, network mask and default route. The address and mask settings are required. The default route is not strictly necessary, but enables network communication between the test set and devices on a subnet other than that to which it is immediately attached. The network features can be used on the local area network, even if no default route (specified as 0.0.0.0) is configured.

The command and data ports can also be changed if the default port numbers conflict with other ports on the network. They are used to remotely control the test set and access collected data.

To configure the network connection with a static IP address:

1. Obtain the following information from your network administrator:

IP Address: _____

Subnet Mask: _____

Default Route: _____

2. From the front panel, press **Settings and Options** (see “3.1.1 Navigation” on page 12).
3. Press **Settings**.
4. Press **Network**.
5. Use the down arrow softkey to focus (denoted by highlight on the input components) the row labeled *Address Assignment*.
6. Press the right arrow softkey to toggle the setting to *Static Address*.
 - The spin buttons for the IP address, network mask and default route octets become sensitive (they are grayed out for the *DHCP* method).
7. Press the down arrow softkey to move to the row labeled *IP Address*. Press the right arrow softkey to access and set the individual octets as described in “3.4.1 Numeric Parameters” on page 16.
8. Press the down arrow softkey to focus the row labeled *Network Mask* and repeat step 7 for the network mask obtained in step 1.
9. Press the down arrow softkey to focus the row labeled *Default Route* and repeat step 7 for the default route obtained in step 1. A default route value of 0.0.0.0 specifies that no default route is required.
10. Press **Apply** to save the new settings.
 - The settings screen is reactivated. It reflects the new network configuration.

4.1.2.2 DHCP Network Configuration

When network parameters are configured using *DHCP*, the test set obtains address and routing information from a server. The server reserves these parameter values for the test set for an amount of time which depends on the server's configuration. Near the end of this period, the *DHCP* client application (on the test set) requests an extension, at which point the server renews this reservation and this cycle repeats. The test set is said to "obtain a lease" from the server, and is said to "renew the lease" shortly before it expires.

When the unit is powered on with *DCHP* configuration enabled, or is reconfigured from static configuration to *DHCP*, it makes attempts to obtain a lease from a server. If a server cannot be contacted, or a lease cannot be granted because no addresses are available, the test set will make another request every few minutes.

Early versions of test sets cannot detect an Ethernet carrier. This can cause a noticeable delay in initial lease acquisition when it is connected to a network after it has been powered on. The delay results from a sequence of events similar to the following:

1. The test set requests a lease and fails because it is not connected to a network.
2. Another attempt is scheduled to run 3 minutes later.
3. 1 minute after the next attempt has been scheduled, the test set is attached to the network.
4. The test set does not request a lease for another 2 minutes - it scheduled the next request to run 3 minutes after the failed attempt 1 minute ago.

The test set can be forced to request a lease by restarting the DHCP client application. A push button on the network settings screen is used for this purpose.

To restart the DHCP client:

1. Navigate to the **Settings** screen (see "4.1 The Settings Screen" on page 21).
2. Press **Network**.
3. Press the down arrow softkey until focus (denoted by a white rectangle) reaches a push button on the row labeled *Operations*.
 - The softkey interface displays a **PUSH** softkey
4. Press the right arrow softkey until the *Restart DHCP* button is focused.
5. Press the **PUSH** softkey to push the focused button and restart the DHCP client.
 - A dialog confirms that the client application has been restarted and is requesting a new lease.
6. Press **Dismiss Dialog**.
7. Press **Apply** or **Cancel** to return to the settings page.
 - The *IP Address*, *Network Mask* and *Default Route* fields on the Settings screen are updated with the server provided values as soon as the unit is able to obtain a lease.



Note

On test sets that can detect presence or absence of Ethernet carrier, the DHCP client is restarted automatically when the unit is connected to the network. Test sets that can detect carrier, display either "no carrier" or "active" in the *Ethernet Carrier* field on the Settings screen. Test sets which cannot detect carrier always display "unknown" in the *Ethernet Carrier* field.

4.1.3 Printer Configuration

Whenever the **Print** button on the front panel is pressed, or print commands arrive on the network command interface, the TSC 5120A or 5115A prints to the current print job destination in the current format.

The test set can print plots, tables and the settings screen in two formats:

- *PCL5* - Printer Control Language 5 format which PCL5-capable printers will accept. Printers of level PCL4 or below cannot use this format. Refer to the printer's documentation to determine its compatibility.
- *PostScript* - Raw PostScript that only PostScript printers will accept.

Print jobs can be sent to one of three destinations:

- *Local* - A USB printer attached to the test set. See “4.1.3.1 Printing to a USB Printer” on page 26.
- *File* - A file on the test set's file system. These files are accessed via anonymous File Transfer Protocol (FTP). See “4.1.3.2 Printing to Files” on page 27 for details.
- *Network* - A network printer that supports direct transfer of information to a port such as the HP JetDirect using port 9100. Other spooling protocols, such as the Internet Printing Protocol (IPP), are not currently supported.

Note that section “4.1.2 Network Configuration” on page 23 must be completed before jobs can be sent to a network printer or retrieved by using FTP.

To configure printing:

1. Navigate to the **Settings** screen (see “4.1 The Settings Screen” on page 21).
2. Press **Printing**.
3. Use the arrow keys to select a destination for print jobs (see “3.4.2 Mutually Exclusive Options” on page 18 for details).
 - If you selected the *Network* destination, the IP address and port number in the fields labeled *Remote Host* and *Remote Port* became sensitive.
4. Use the arrow keys to toggle the print format (a mutually exclusive option).
5. Press **Apply** to save the new configuration.
 - The settings screen is reactivated. It reflects the new configuration.

4.1.3.1 Printing to a USB Printer

To print to a USB Printer:

1. Attach a PCL5 or PostScript capable printer to one of the USB ports shown in [Figure 2](#), on [page 5](#) or a USB hub connected to one of these ports.
2. Configure the test set to print to the *Local* destination in the format the printer supports.
3. Print the data sets of interest using the methods described in sections “6.2 Printing” on page 52 and “7.2.4 Printing from the Command Port” on page 59.

4.1.3.2 Printing to Files

When the test set is configured to print to files, output that is normally sent to a USB or network printer is stored on its file system instead. The test set will store up to fifteen print jobs. Jobs are numbered starting at zero. Once all possible files are in use, the test set wraps around and starts overwriting the oldest print job with the current one. Print job files are stored in the current print format and compressed. The format and compression are indicated by file extensions:

- `print0.pcl.gz` (*.pcl* denotes PCL5 format and *.gz* that the file is compressed)
- `print1.ps.gz` (*.ps* denotes PostScript format and *.gz* that the file is compressed)

Print jobs written to files are stored in the *printfiles* directory. This directory is accessible via anonymous FTP. Its contents (the print jobs) are erased when the test set is powered off.

To retrieve print jobs sent to files:

1. Access the test set with an ftp client using anonymous login (you will not need a password).
 - See [Figure 8, on page 21](#) to determine the test set's IP address.



Note

Be sure to configure the ftp client for binary file transfer. Most command line based ftp clients accept the **bin** command for this purpose. See your ftp client software documentation for details on how to set binary file transfer.

2. Download the files from the *printfiles* directory.

The following is a transcript of a sample command line ftp session. Input from you is shown in **bold** text. Note that the test set will have a different IP address:

```
OS command prompt> ftp 206.168.13.249
Connected to 206.168.13.249.
220 ts FTP server (Version 6.00LS) ready.
User (206.168.13.249:(none)): anonymous
331 Guest login ok, send your email address as password.
Password: (no password required - just press enter here)
ftp> cd printfiles
ftp> bin
200 Type set to I.
ftp> get print0.ps.gz
150 Opening BINARY mode data connection for 'print0.ps.gz' (17358 bytes).
226 Transfer complete.
ftp> bye
```

The *print0.ps.gz* file is now on the computer from which the ftp session was initiated. The file can now be decompressed and viewed or printed using third party software such as Ghostview.

4.1.3.3 Configuring Network Printers

The network printing feature requires a network printer that supports direct transfer of information to a port.

1. Configure the test set network connection, following section “4.1.2 Network Configuration” on page 23.
2. Set the test set to print to the *Network* destination in the format the printer supports.
3. Enter the IP address and port number of the target printer.
4. Press **Apply** to save the new configuration.

4.1.4 Viewing Version Information

You can view the model number, software version and hardware CPLD revision numbers when needed for troubleshooting.

To view the model number and software version:

1. Navigate to the **Settings** screen (see “4.1 The Settings Screen” on page 21).
2. Press **Version Info** to access version information.
3. Press **Return** to go back to previous screens.

4.1.5 Restoring Factory Default Settings

Parameters configured using the Settings submenus persist when the test set is power cycled. Other settings such as the frequency counter’s user supplied reference frequency and test masks also persist. All persisted settings can be reset to the values the TSC 5120A or 5115A was shipped with, using the following steps.

To restore all settings to factory default values:

1. Navigate to the **Settings** screen (see “4.1 The Settings Screen” on page 21).
2. Press **Restore Factory Defaults**.
 - A screen with information about the settings restoration operation is displayed.
3. Press **Restore Factory Defaults**.
 - A dialog requesting final confirmation that all settings are to be restored to default values is shown.
4. Press **Yes**.
 - The test set deletes the current parameter values from persistent storage and reboots. After it restarts, a dialog confirming that default values have been restored is displayed.

5: Configuring the Data Sets

5.1 Configuring Phase Noise Data

The TSC 5120A and 5115A display $\mathcal{L}(f)$ phase noise data out to 100 kHz. This data shows the $\mathcal{L}(f)$ spectrum of the phase differences between the Input and Reference signals. All measurements are referenced to the frequency of the Input signal.

Data first displays on the screen after collection starts, then the screen updates as often as a few times per second. The first range of data displayed is from approximately 0.1 Hz to 100 kHz. The longer the data collection period, the more data is available to display phase noise at lower offset frequencies.

The test set detects spurs caused by its own operation. These spurs are referred to as internally generated spurs. Internally generated spurs are removed from calculations. All spurs plotted on the phase noise plot are part of the signals attached to Input or Reference port.

Figure 9 shows an example phase noise plot.

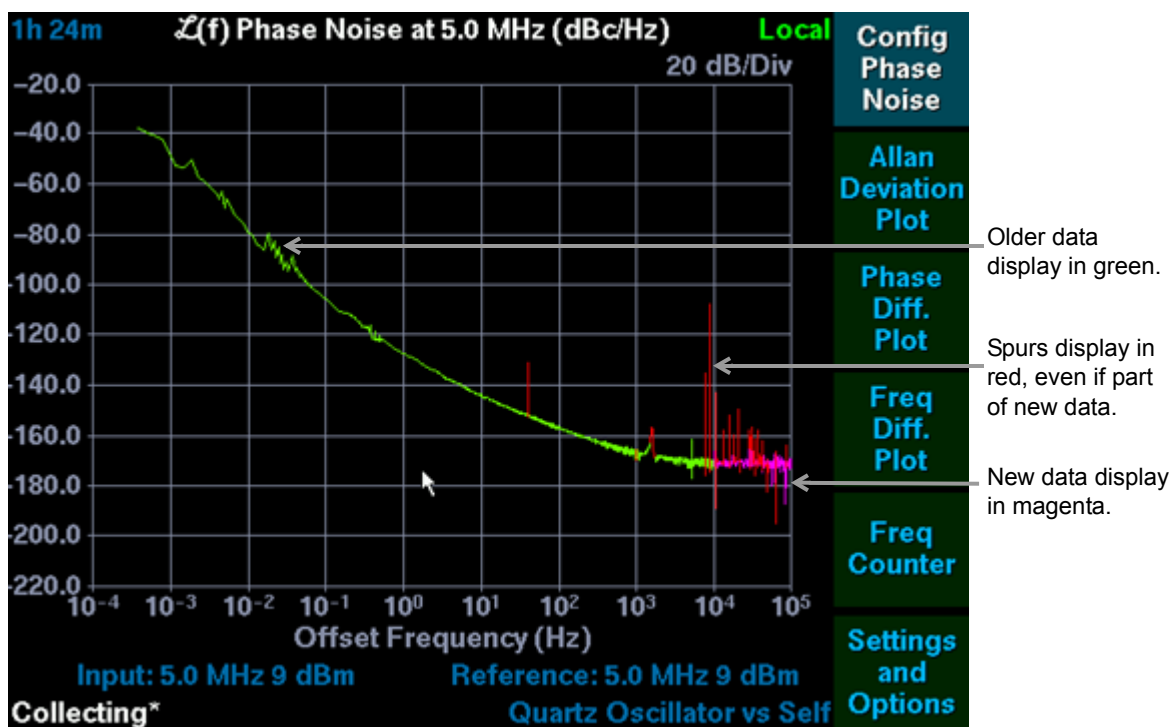


Figure 9: Example phase noise plot

The following phase noise settings can be configured:

- Plot Scale (see [page 30](#))
- Data Markers (see [page 32](#))
- Test Mask (see [page 35](#))
- Display Tools (see [page 38](#))

5.1.1 Scaling the Phase Noise Plot

The phase noise plot can be scaled logarithmically or linearly in the following ways:

- Automatically scale the y axis:
 - Sets the dB/division to the closest values that allow display of all data.
 - Sets the top grid line to a multiple of the selected dB/division value.
- Manually scale the y axis:
 - Allows for shifting by division.
 - Lets you increase or decrease the dB/division allowing the following values: 0.1, 0.15, 0.2, 0.5, 1, 1.5, 2, 5, 10, 15, 20, 25 and 30.
- Automatically scale the x axis:
 - Sets the x scale to logarithmic.
 - Sets the minimum and maximum frequency to fit all data.
- Fixed logarithmic scale x:
 - Shows from 1 to 9 decades.
 - Allows the following values (Hz): 10^{-4} , 10^{-3} , 10^{-2} , 10^{-1} , 10^0 , 10^1 , 10^2 , 10^3 , 10^4 , and 10^5 .
- Fixed linear scale x:
 - Forces minimum x value of 0 Hz.
 - Allows the following maximum values (Hz): 10^{-3} , 10^{-2} , 10^{-1} , 10^0 , 10^1 , 10^2 , 10^3 , 10^4 , and 10^5 .

To scale the plot using softkeys:

1. Navigate to the **Phase Noise Plot**. See “3.1.1 Navigation” on page 12 for details.
2. Press **Config Phase Noise**.
3. Press **Scale Plot**.
 - The highlighted softkeys show whether each axis is auto scaled or in fixed scale mode.
 - To auto scale an axis, press **Auto Scale X Axis** or **Auto Scale Y Axis**.
 - To manually scale an axis, press one of the following:
 - **Fixed Scale Y Axis**
 - Use **Shift Up 1 Div** and **Shift Down 1 Div** to shift (scroll) the data up or down one division on the screen.
 - Use **Increase dB/Div** or **Decrease dB/Div** to increase or decrease the values for each division on the plot.
 - **Scale X-log**
 - Use **Inc Max** or **Dec Max** to increase or decrease the maximum value on the scale.

- Use **Inc Min** or **Dec Min** to increase or decrease the minimum value on the scale.
- **Scale X-linear**
 - Use **Inc Max** or **Dec Max** to increase or decrease the maximum value on the scale.

If a USB mouse is attached to the test set, the plot can be manually scaled very effectively by zooming in on a region of interest. This region is designated by dragging a rectangle around it.

To scale the phase noise plot using a mouse:

1. Right-click anywhere on the plot and select **Scale > Zoom**.
 - The mouse cursor changes to a cross hair.
 - Tip: Invoke this function by pressing the ‘Z’ key on a USB keyboard.
 - Tip: Cancel the zoom operation by clicking the right mouse button. Do so at any point in this instruction set.
2. Move the mouse to one corner of the region of interest.
3. Press (and hold) the left mouse button.
4. Move the mouse to the opposite corner of the region of interest.
 - As the mouse is moved, a white rectangle from the original corner to the current mouse position is continually drawn.
5. Release the left mouse button to zoom in on the selected region.
 - The phase noise plot is scaled to fit all data in the selected region.
 - Both the x and the y axis are switched to fixed scale mode.

The fixed scales produced by the zoom feature are subject to the same constraints described above. The zoom feature cannot scale the x axis below a single decade in logarithmic mode.

If the mouse has a wheel, the equivalent of the **Shift Up 1 Div** and **Shift Down 1 Div** softkey functions for the y axis can be performed by scrolling the wheel. Note that this operation puts the y axis into fixed scale mode.

The mouse can quickly auto scale both the x axis and y axis. Right-click on the plot and select **Scale > Auto Scale**. This function can be invoked by pressing the ‘A’ key on a USB keyboard.

5.1.2 Setting Data Markers

Data markers designate two specific frequencies, each with a diamond on the screen. These are referred to as the marker and the delta marker. Once markers are positioned on a frequency, they continue to display the measurement at that frequency until they are repositioned.

Both markers display their frequency and power spectral density values at the top of the phase noise plot screen. This is useful because it provides more accurate coordinates than the plotted data itself can indicate. The coordinates are updated as markers are repositioned or trace a new measurement at their designated frequency.

When both markers are positioned, the difference between their coordinates is calculated and displayed.

When either marker is tracing a measurement that is part of a spur, a small color coded window pops up to indicate the spur's frequency and power. The spur information window moves to another quadrant if the plot is scaled so that the marker indicator collides with the window.

A placed marker is considered visible even if the plot is scaled so that its indicator falls off the screen. A visible marker's spur information window remains visible as a result. When you **Hide Markers**, their indicators and any extra window are hidden as well. Any extra windows visible at the time the phase noise plot is printed will appear on the printout. Note that the marker coordinates at the top of the screen overlap the title as a result of limited screen resolution. Printouts have a much higher resolution and the marker coordinates are printed below the main title instead of obscuring it.

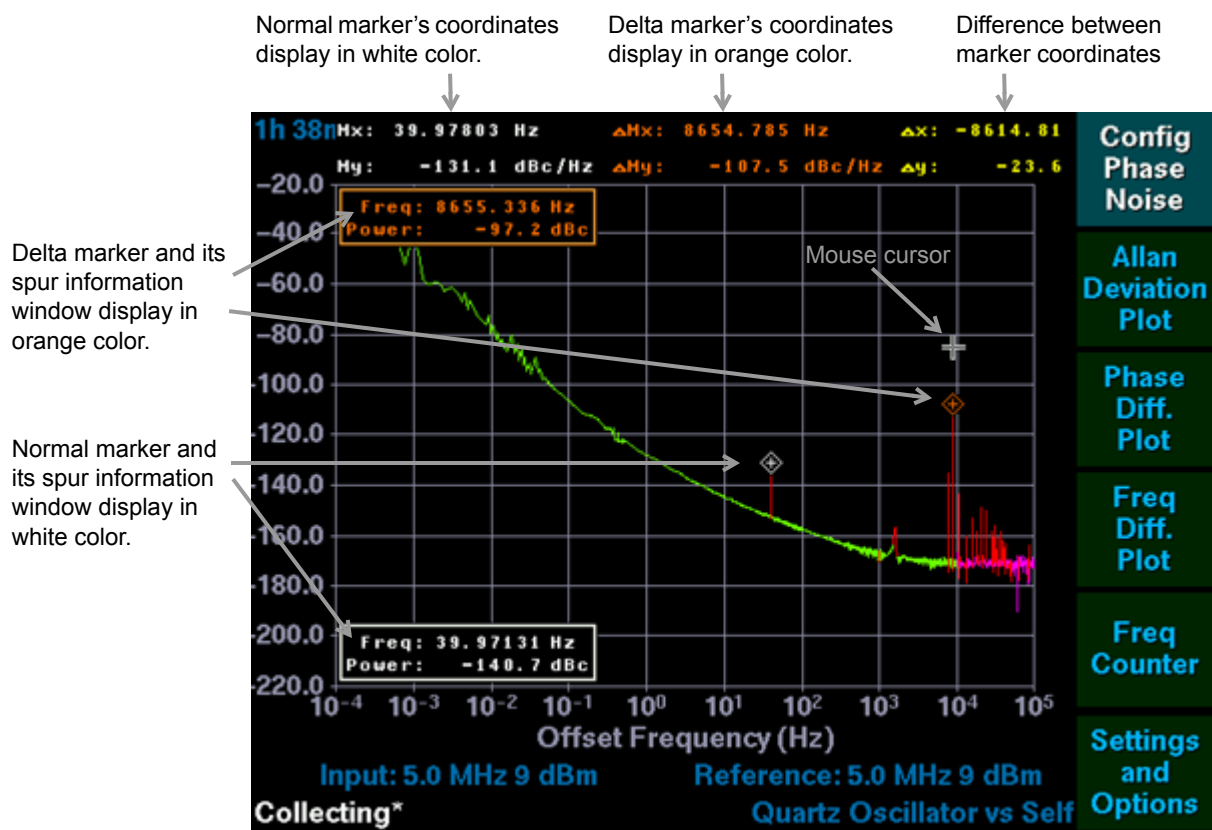





Figure 10: Example phase noise data with data markers

To place markers using the softkey interface:

1. Navigate to the **Phase Noise Plot**. See “3.1.1 Navigation” on page 12 for details.
2. Press **Config Phase Noise**.
3. Press **Markers**.
4. Press **Normal Marker** or **Delta Marker**.
 - A marker (diamond) displays at the center of the plot and its coordinates display at the top of the screen.
5. Use the arrow softkeys to move the marker to the frequency of interest.
 - The left and right arrows move the marker to the next data point in the plot in the direction of the arrow. These are repeating, accelerating softkeys. Pressing and holding the key, the marker moves by a single point a few times, then in increments of 2 points a few times, then 4, increasing by a factor of 2, until 64 points at a time are skipped - at this rate the entire data set can be traced in a reasonable amount of time. Note that movement in terms of data points is not possible while no data set is plotted.
 - The  and  softkeys move the marker to the offset frequency at the next vertical grid line.
 - The  softkey moves the marker to the center of the x axis.

To place a marker using the mouse:

1. Right-click anywhere on the phase noise plot and select **Markers > Place Marker** or **Markers > Place Δ Marker**.
 - Tip: These functions can be invoked by pressing the ‘M’ or ‘D’ key on a USB keyboard.
 - The mouse cursor changes to a cross hair as shown above the delta marker in [Figure 10](#).
2. Move the mouse.
 - The marker follows the x-coordinate of the mouse cursor.
 - Tip: Due to limitations imposed by screen resolution, multiple data points are plotted at the same x-coordinate. Mouse-based marker placement also considers the y-coordinate when selecting the best matched measurement. The mouse was used to place the delta marker in [Figure 10](#). Note that the cross hair mouse cursor is above the actual measurement traced by the marker. This ensures that the marker is placed on the highest data point at that offset frequency. If the mouse cursor was at the same x coordinate but below the data set, the lowest point at that x coordinate would have been selected.
3. Click the left mouse button to position the marker.

To remove all markers and related information windows:

1. From the front panel, press **Phase Noise Plot**.
2. Press **Config Phase Noise**.
3. Press **Markers**.
4. Press **Hide Markers**.
 - All markers and windows are removed from the screen.

Alternatively, right-click the phase noise plot at any time and select **Markers > Hide**. The marker softkey interface need not be active.

Once a marker is placed at a frequency it will follow the measurement at the frequency closest to it. This “best match measurement” is calculated every time new data becomes available. Consider the following scenario to understand why this is relevant:

1. The test set has measured phase noise for 30 minutes and measurements at offset frequencies below 10^{-3} Hz are available.
2. A marker is placed at an offset frequency of 0.012 Hz.
3. Data collection is stopped and restarted. Phase noise data at 0.012 Hz will not be available for some time. Until it becomes available, the measurement whose frequency most closely matches that of the marker position is the measurement with the lowest offset frequency. The marker follows this measurement. When a measurement at (or below) 0.012 Hz is available the marker stops moving in frequency and begins to continually follow the 0.012 Hz measurement.



Note

Markers can also be placed on a specific spur’s frequency using the Spur Table. For more information on how to do so see [“5.1.5 The Spur Table”](#) on page 38.

5.1.3 Setting Up a Test Mask

Test masks display a visual fail level reference line for phase noise data. A test mask is a set of line segment end points that are scaled as data points are. Line segments are drawn between the points after scaling. Note that a test mask must contain at least two points before a line segment appears on the plot.

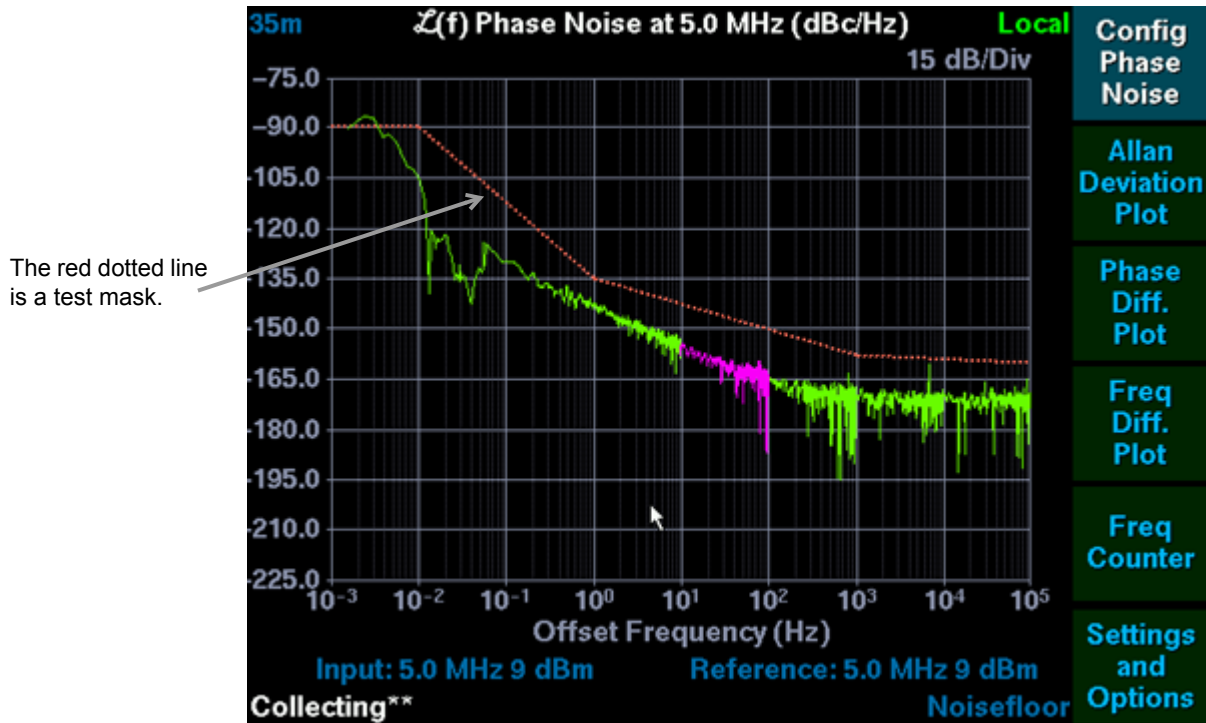


Figure 11: Example test mask for phase noise

The TSC 5120A and 5115A can store five different phase noise test masks. One of them is considered to be the current test mask. The current test mask changes as masks are loaded and saved. The current mask is highlighted in the editor's load and save softkey interfaces. It is marked with a dot in the mouse popup menu. Loading, saving and editing of test masks is done with the test mask editor.

To access the test mask editor:

1. Select the **Phase Noise Plot** (see “3.1.1 Navigation” on page 12 for details).
2. Press **Config Phase Noise**.
3. Press **Test Mask**.
4. The Test Mask Editor is activated and displays the points in the current test mask. The current test mask is empty when the phase noise test set is shipped. Figure 12 on page 36 shows the test mask editor for the test mask shown in Figure 11.

The test mask editor provides the softkey interface to edit, load and save test masks.

Press **Edit Mask** to edit the current test mask.

Toggles visibility of the current test mask. Displays **Show Mask** when mask is hidden, or **Hide Mask** when mask is visible.

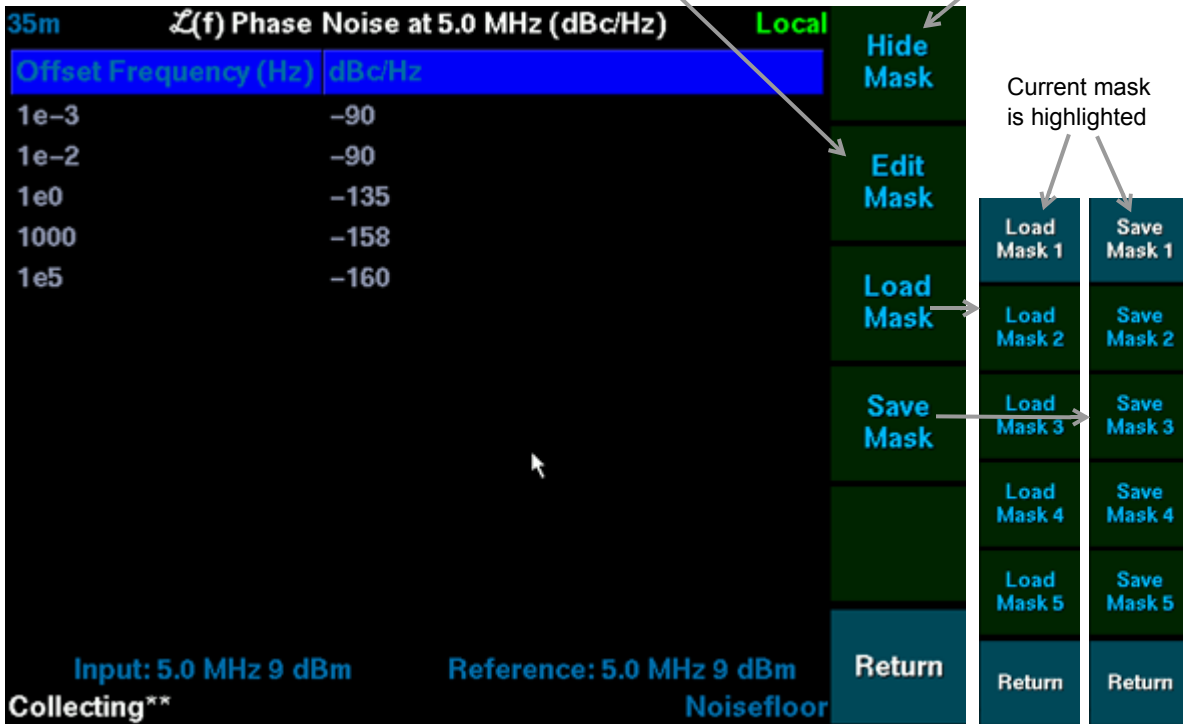


Figure 12: The test mask editor

Adding or editing points requires input of an x and a y coordinate. The number pad editor is executed twice each time a point is added or edited. When adding new points, the number pad editor is initialized with blank fields. When editing existing points, it is initialized with each coordinate's current value. This simplifies modification of only one of an existing point's coordinates.

To edit a test mask:

1. Access the test mask editor as described in “[To access the test mask editor:](#)” on page 35.
2. Press **Edit Mask**.
 - The softkey interface changes to provide an interface with the interactive table.
3. Press **Add Point** to add a new point to the test mask or go to [Step 4](#) to edit existing points or [Step 6](#) to delete points.
 - Tip: Right-click the test mask table and select **Add Point** in the menu without entering the **Edit Mask** interface.
 - “[3.4.1.1 The Number Pad Editor](#)” on page 17 is displayed for the first coordinate.
 - Enter the *Offset Frequency* coordinate (in Hz) for the new point and press **Apply**, or press **Cancel** to cancel point addition.
 - If the first coordinate was applied, the number pad editor is displayed for the second coordinate.

- Enter the *dBc/Hz* coordinate for the new point and press **Apply**, or press **Cancel** to cancel the addition.
 - If addition was not cancelled, the table lists the new point.
4. Use the arrow softkeys to highlight a point to edit.
 5. Press **Edit Point**.
 - Tip: Steps 4 and 5 can be combined by double clicking the point to be edited with a mouse. This can be done without entering the table's interactive softkey interface as stated in [Step 2](#).
 - “3.4.1.1 The Number Pad Editor” on page 17 is displayed for the first coordinate.
 - Edit the *Offset Frequency* coordinate (in Hz) and press **Apply**, or press **Cancel** to cancel the edit.
 - The number pad editor is displayed for the second coordinate.
 - Edit the *dBc/Hz* coordinate and press **Apply**, or press **Cancel** to cancel the edit. When an edit is cancelled, both of the test mask point's coordinates remain unchanged.
 - If editing was not cancelled, the point's row in the table is updated with the new coordinates. The point may be moved, as test mask points are ordered according to their x-coordinate.
 6. Use the arrow softkeys to highlight a point to delete.
 7. Press **Delete Point**.
 - With a mouse, points can be deleted by clicking their row, then right-clicking and selecting **Delete Point** from the popup menu. This can be done without entering the **Edit Mask** softkey interface as stated in [Step 2](#).

Any added, edited or deleted points mark the test mask as changed. A warning is displayed upon **Return** to the phase noise plot if a changed mask has not been saved. The message states that modifications will be lost if the unit is powered off.

To save a test mask:

1. Access the test mask editor as described in “[To access the test mask editor:](#)” on page 35.
2. Press **Save Mask**.
 - Note that the test mask that was last loaded or saved is highlighted.
3. Press one of the softkeys (shown on the right in [Figure 12](#)) to save the mask to the corresponding slot.
 - If this will change an existing test mask, the system asks for confirmation before it overwrites the existing mask. The screen displays the current and the original masks in two tables. To overwrite the existing test mask, press **Overwrite**. To save the mask to a different slot, press **Cancel**.
 - A message window confirms that the mask was saved.

To load a test mask:

1. Access the test mask editor as described in “[To access the test mask editor:](#)” on page 35.
2. Press **Load Mask**.

3. Press one of the softkeys (shown on the right in [Figure 12](#)) to load the test mask stored in the corresponding slot.
 - The table on the left displays the loaded test mask.
 - The pressed softkey is highlighted. The loaded mask has become the current mask.
4. Press **Return**.
5. Make sure the mask will be plotted. The topmost softkey in the test mask editor will read **Hide Mask** if the mask is to be plotted. If it will not be plotted, the softkey is labeled **Show Mask**. Press the **Show Mask** key to enable plotting the mask.

Test masks can be loaded and saved by right-clicking the plot. Select **Test Mask > Save > Mask 3** in the popup menu to save the current mask as the third mask, for example. Test masks can also be shown and hidden using this menu.

5.1.4 Display Tools

The **Display Tools** softkey available through the **Config Phase Noise** menu accesses a menu with the following softkeys:

- **Pause Updates** stops update of the data display. This softkey toggles to **Resume Updates**.
- **Take Snapshot** displays a snapshot of the data to compare to data as it is being collected. Snapshot data is plotted in white.
- **Hide Snapshot** toggles with **Show Snapshot** to disable/enable plotting of the snapshot.
- **Integrated Phase Noise** accesses a read-only table that displays integrated phase noise with and without spurs. Each row shows integrated phase noise for one lower limit. As the phase noise data set grows, additional rows appear for even lower limits. See “[3.3.2 Tables](#)” on page 15 for more information about read-only tables.

5.1.5 The Spur Table

The spur table is an interactive table that lists all the spurs in the plotted phase noise data. See “[3.3.2 Tables](#)” on page 15 for more information on interactive tables.

The test set detects spurs caused by its own operation. These spurs are referred to as internally generated spurs. Internally generated spurs are removed from calculations. All spurs listed in the spur table are part of the signals attached to Input or Reference port.

Every spur’s frequency and power is listed regardless of how the phase noise plot is scaled. Spurs that do not appear on the plot are listed as such.

To access the spur table:

1. From the phase noise plot, press **Config Phase Noise**.
2. Press **View Spur Table**.

Alternatively, one can right-click the plot and select **View Spur Table**.

One can **Pause Updates** and **Resume Updates** to the phase noise plot, and hence the spur table itself, from the softkey interface provided by the table. This is equivalent to pausing and resuming updates from the **Display Tools** softkey menu described in the previous section. **Pausing Updates** makes reading the screen easier and simplifies marker placement.

The marker or delta marker can be placed on a spur's frequency for easier identification on the phase noise plot.

To place a marker at a spur's frequency:

1. Use the arrow softkeys to highlight a spur.
 - Tip: Click the desired spur with a mouse.
2. Press **Place Marker** or **Place Δ Marker**.

For general information about markers, see “[5.1.2 Setting Data Markers](#)” on page 32.

5.2 Configuring the Allan Deviation Plot

The 5120A and 5115A can display the Allan deviation of the input signals. This data shows how much phase deviation there is over time between the Input signal and the Reference signal. All measurements are referenced to the Input signal.

The Allan deviation screen shows the following:

- Allan deviation plot of the collected data.
- Current τ_0 value displays in the upper-left corner.
- Noise Equivalent Bandwidth of the input filter, *NEQBW*, is displayed in the upper right corner. NEQBW describes the equivalent bandwidth of a filter for broadband (white) noise and is the bandwidth of a rectangular characteristic filter having the same power transfer function as the selection filter (same area under the curve).

The following can be configured:

- Plot scale (see [page 40](#))
- τ_0 setting (see [page 41](#))
- Test mask (see [page 41](#))

5.2.1 Scaling the Allan Deviation Plot

The Allan deviation plot can be scaled automatically or manually.

To scale the plot:

1. Press **Allan Deviation Plot** (see “[3.1.1 Navigation](#)” on page 12 for details).
2. Press **Config Allan Deviation**.
3. Press **Scale Plot**.
 - The highlighted softkeys show the current settings.
 - Press **Auto Scale X Axis** or **Auto Scale Y Axis** to auto scale either axis.
 - To scale the plot manually, press one of the following:
 - **Fixed Scale Y Axis**
 - Use **Inc Min** or **Dec Min** to increase or decrease the minimum scale value.
 - Use **Inc Max** or **Dec Max** to increase or decrease the maximum scale value.
 - **Fixed Scale X Axis**
 - Use **Inc Min** or **Dec Min** to increase or decrease the minimum scale value.
 - Use **Inc Max** or **Dec Max** to increase or decrease the maximum scale value.



Note

The Allan deviation plot can be scaled using the zoom feature described for the phase noise plot. See “[To scale the phase noise plot using a mouse:](#)” on page 31 for details.

5.2.2 Selecting τ_0

The τ_0 value is the smallest sampling period used to calculate a set of Allan deviation values. These values are computed at averaging times that are multiples of the base τ_0 . The available τ_0 values are: 1 ms, 10 ms, 100 ms, and 1 s.

To select the τ_0 :

1. Navigate to the **Allan Deviation Plot** (see “3.1.1 Navigation” on page 12).
2. Press **Config Allan Deviation**.
3. Press **Select τ_0** .
4. Increase or decrease the τ_0 setting using the **Inc τ_0** or **Dec τ_0** softkeys.

To set τ_0 with a mouse, right-click the plot and select the desired value from the **Set τ_0** submenu. The current selection is indicated with a dot before the menu item.

5.2.3 Viewing the Allan Deviation Table

Allan deviation data can be viewed in tabular format by pressing the **View Table** softkey. The table lists all Allan deviation values regardless of how the plot is scaled.

To access the table with a mouse, right-click the Allan deviation plot and select **View Table** from the menu. The table provides both the softkey and mouse interfaces to change the τ_0 value.

5.2.4 Setting Up Allan Deviation Test Masks

The Allan deviation test mask is configured in the same way the phase noise test mask is. The plot maintains its own set of persistent test masks. Saving an Allan deviation test mask as Mask 3 does not overwrite the corresponding phase noise test mask, for example.

To set up the Allan deviation test mask:

1. Navigate to the **Allan Deviation Plot** (see “3.1.1 Navigation” on page 12).
2. Press **Config Allan Deviation**.
3. Press **Test Mask**.
 - The test mask editor has been invoked. Loading, editing, saving, showing and hiding the Allan deviation test mask work just as described in section “5.1.3 Setting Up a Test Mask” on page 35. The differences you will encounter are units in the test mask tables and number pad editor, and the main screen title. Both help determine for which plot the test mask editor has been invoked.

5.3 Configuring the Phase Difference Plot

The phase difference plot shows real-time measurements each second. After approximately nine minutes, the data pans to the right as new data becomes visible. All measurements are referenced to the Input signal.

The phase difference plot shows the following:

- Value of the center line, or its origin and slope when linear trend is removed. See “5.3.2 Removing the Linear Trend” on page 43 for details.
- Value per division on the y axis in seconds.
- Value per division of the x axis in seconds. This cannot be changed.

5.3.1 Scaling the Phase Difference Plot

The phase difference plot can:

- automatically scale the y axis to fit all data
- display the y axis in fixed scale mode

The x axis displays 60 seconds of data per division.

To scale the plot:

1. Press **Phase Diff Plot** (see “3.1.1 Navigation” on page 12).
2. Press **Config Phase Diff**.
 - To automatically scale the y axis, press **Auto Scale Y Axis**.
 - To use a fixed scale, press **Fixed Scale Y Axis**, then press one of the following:
 - Use **Shift Up 1 Div** and **Shift Down 1 Div** to shift (scroll) the data up or down one division on the screen.
 - Use **Increase Time/Div** or **Decrease Time/Div** to increase or decrease the values for each division on the plot.
 - Use **Center Median** to center the data’s median vertical value.

5.3.2 Removing the Linear Trend

Phase difference measurements often exhibit a linear trend. This results in plots which appear as diagonal "lines" when they are scaled in a way that fits all data. This is the result of a large units per division selection on the y axis, which in turn results from accommodation of the oldest and the most recent measurement which continually grow further apart. The large units per division setting decreases resolution and makes it difficult to observe measurement details.

Consider the phase difference measurements plotted in [Figure 13](#). Over time they exhibit the trend discussed thus far. The white line segment shows this trend, as it is measured by the **Measure Linear** softkey. The slope of this line segment (from the first to the last available measurement) is taken into consideration when the trend is measured.

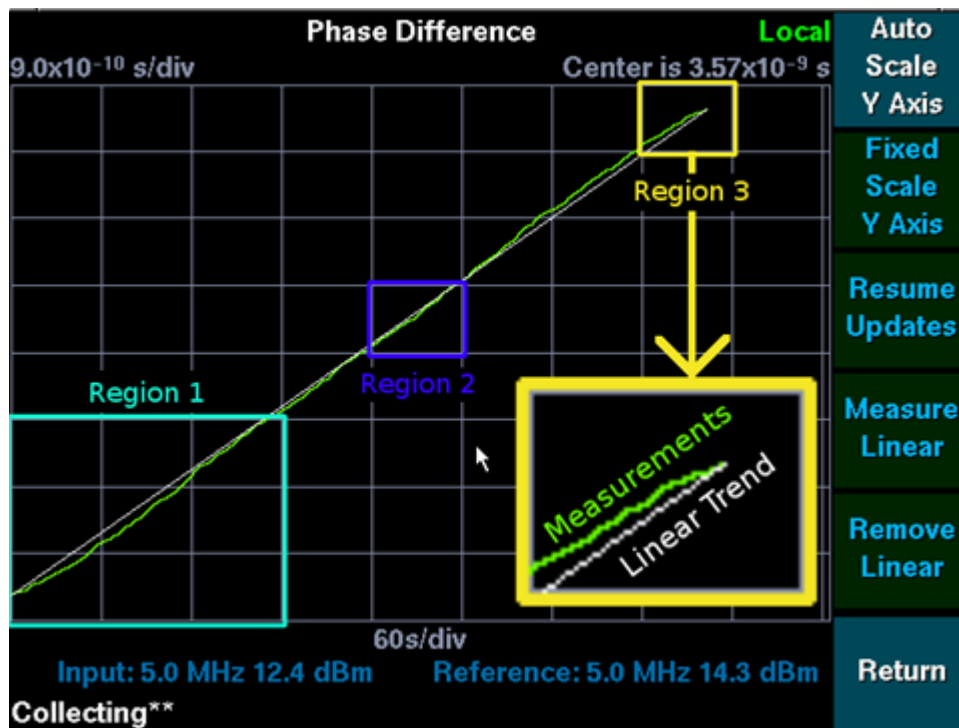


Figure 13: Linear trend in phase difference measurements

Make the following observations about [Figure 13](#):

- Region 1 contains measurements which fall below the trend line, and reach the trend line towards the end of the region.
- Region 2 contains measurements near or on the trend line segment.
- Region 3 holds measurements which approach the trend line segment from above.

Once the trend has been measured, it can be removed from the plotted measurements, by pressing the **Remove Linear** softkey shown in [Figure 13](#). Removing the linear trend from this data set results in the display shown in [Figure 14](#):

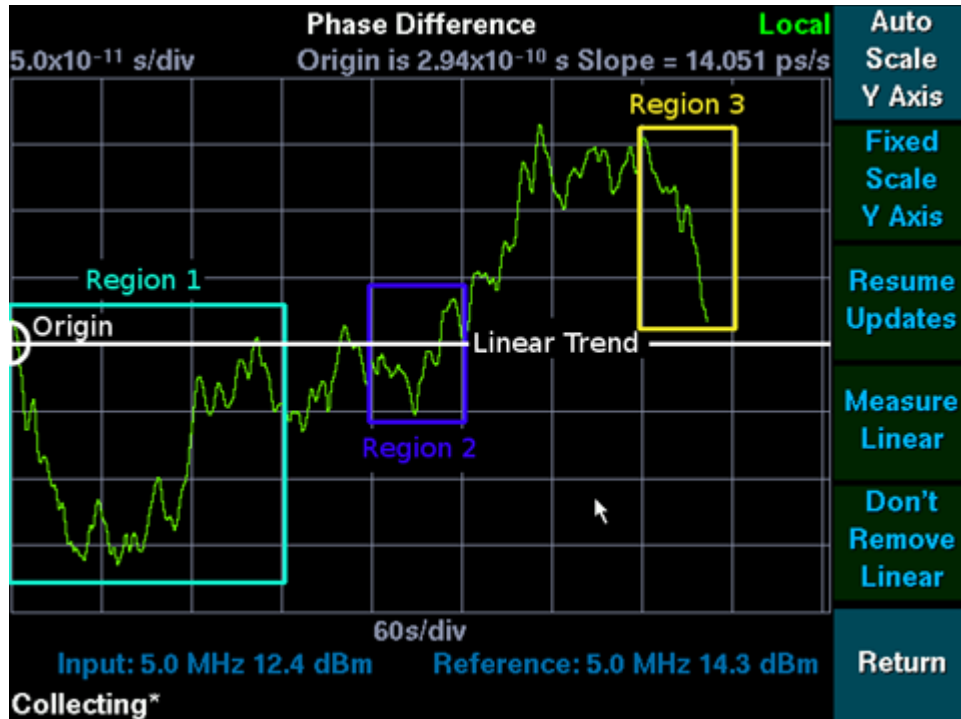


Figure 14: Linear trend removed

Make the following observations about Figure 14:

- The y axis no longer lists the plot's center coordinate (in the top right corner) but refers to *Origin* and the linear trend's *Slope*.
- The origin is the center y-coordinate at the left most grid line.
- *Slope* shows by how much the white line labeled Linear in Figure 14 was adjusted. It is the slope of the line through the oldest and most recent measurement at the time the linear trend was measured using the **Measure Linear** softkey.

Compare each of the rectangular regions with its counter part in Figure 13.

- The curves above and below the trend are better defined.
- Trend line intersections which were barely noticeable in Figure 13 can readily be seen.

The **Remove Linear** softkey has changed to **Don't Remove Linear**. Pressing it at this time will stop removing the trend from the data and display data set as seen in Figure 13.

The linear trend can be measured whenever there are at least two phase difference measurements available. Slope and origin are computed against the actual measurements even if the trend is currently removed. There is no need to stop removing the trend before measuring it again.

If linear trend removal results in a plot that exhibits a linear trend of its own, the phase difference measurements are following a curve rather than a line.

Pressing the **Remove Linear** softkey essentially plots the phase difference measurements' distance from the trend last measured by the **Measure Linear** softkey. The top and bottom most grid lines in [Figure 14](#) are parallel to the linear trend line segment in [Figure 13](#), as depicted in [Figure 15](#):

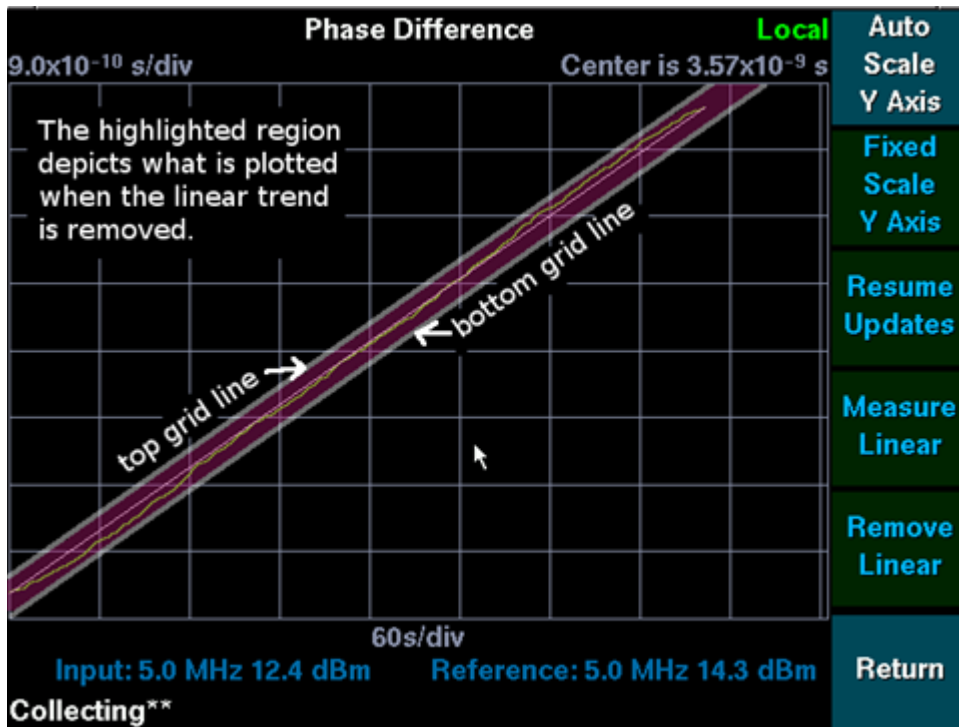


Figure 15: Conceptual Representation of [Figure 14](#) in terms of [Figure 13](#).

5.3.3 Pausing or Resuming Updates

The phase difference measurement display can be paused by pressing the **Pause Updates** softkey. To resume updates, press the **Resume Updates** softkey. As with all data sets that can be paused, the test set continues to collect data while updates are paused and presents the latest data set when they are resumed.

5.4 Configuring the Frequency Difference Plot

The 5120A and 5115A can display the frequency difference between the Input and the Reference signals. The measurements are plotted in real-time each second. All measurements are referenced to the Input signal. After approximately nine minutes, the data pans to the right so that new data becomes visible.

The frequency difference plot shows the following:

- Value of the center line.
- Value per division on the y axis.
- Value per division of the x axis, in seconds. This cannot be changed.

5.4.1 Scaling the Frequency Difference Plot

The frequency difference plot can be scaled in the following ways:

- automatically scale the y axis to fit all data
- display the y axis in fixed scale mode

The x axis scale is 60 seconds per division and displays about nine minutes of data.

To scale the plot:

1. Press **Freq Diff Plot** (see “3.1.1 Navigation” on page 12).
2. Press **Config Freq Diff**.
 - To automatically scale the y axis, press **Auto Scale Y Axis**.
 - To manually scale it, press **Fixed Scale Y Axis**, then press one of the following:
 - Use **Shift Up 1 Div** and **Shift Down 1 Div** to shift (scroll) the data up or down one division on the screen.
 - Use **Increase Units/Div** or **Decrease Units/Div** to increase or decrease the values for each division on the plot.
 - Use **Center Median** to center the data’s median value.

5.4.2 Pausing or Resuming Updates

The frequency difference measurement display can be paused by pressing the **Pause Updates** softkey. To resume updates, press the **Resume Updates** softkey. As with all data sets that can be paused, the test set continues to collect data while updates are paused and presents the latest data set when they are resumed.

5.5 Configuring the Frequency Counter

The TSC 5120A and 5115A collect data that measures the frequency of the Input signal using the Reference signal as a reference. The test set continually computes and displays frequency averages for the Input signal port for the last 1, 10, 100 and 1000 seconds. When set automatically, the *Reference Frequency* value may be displayed as “*not yet set*” until data collection begins, then the frequency of the Reference port signal is displayed.

The frequency counter table shows the following:

- The average frequency of the Input signal.
- Frequency averages which are continually updated. After 10 seconds, 1 and 10 second averages are displayed, after 1000 seconds all four averages are available.

Frequency averages are output using variable precision. Two factors determine precision:

- The sample time.
- The lower of the frequencies of the signals attached to the Input and the Reference port at the time data collection starts.

The following table shows the number digits following the decimal point based on these factors:

Averaging Time (s)	Frequency <= 1.99 MHz	Frequency <= 4.99 MHz	Frequency > 4.99 MHz
1	13	13	13
10	14	14	14
100	14	14	15
1000	14	14	15

See [Figure 16](#) on page 48 for a frequency counter screen example that shows all four frequency averages at maximum precision.

5.5.1 Changing the Reference Frequency

The reference frequency can be set in one of two ways:

- Automatically - The test set uses the Reference signal's measured frequency.
- Manually - The user specifies a more precise reference frequency.

The current reference frequency displays above the frequency table as shown in Figure 16:

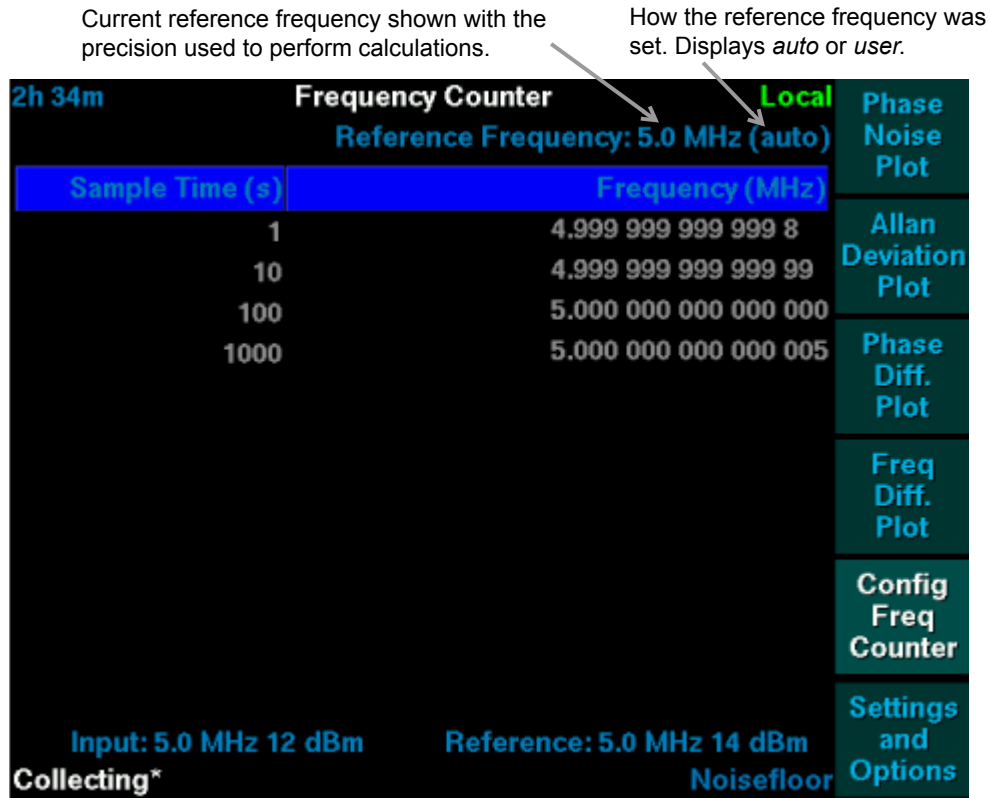


Figure 16: Frequency Counter Screen

5.5.1.1 Automatically Setting the Reference Frequency

The instrument can automatically set the frequency counter's reference frequency when collecting begins. The automatic reference frequency is the frequency of the Reference signal in MHz (to a precision of one decimal digit) at the time collection starts. Automatic setting of the reference frequency is the default setting.

To automatically set the reference frequency:

1. From the front panel, press **Freq Counter** (see "3.1.1 Navigation" on page 12).
2. Press **Config Freq Counter**.
3. Press **Auto Reference Freq**.

5.5.1.2 Manually Setting the Reference Frequency

Manually setting the reference frequency allows for much greater precision than that provided by the automatic setting. A manually entered reference frequency may contain up to 15 decimal digits.

To manually set the reference frequency:

1. From the front panel, press **Freq Counter** (see “3.1.1 Navigation” on page 12).
2. Press **Config Freq Counter**.
3. Press **Enter Reference Freq**.
 - The Reference Frequency number pad editor displays.
4. Enter the new reference frequency (in MHz).
 - See “3.4.1.1 The Number Pad Editor” on page 17 for help with entering numbers.
 - The table of frequencies updates with calculations using the new frequency.
 - The instrument retains the manually set reference frequency until a new one is entered or automatic setting is selected. The frequency setting persists when the test set is powered off.

6: Collecting and Viewing Data Locally

6.1 Starting and Stopping Data Collection

After the TSC 5120A or 5115A is powered up, with Input and Reference signals connected, data collection can be started. For information on configuring the display, see “[Chapter 5, Configuring the Data Sets](#)” on page 29. When the required data is available, collection can be stopped.

To start data collection:

1. Ensure that the reference signal source is connected to the Reference connector and the DUT (device under test) is connected to the Input connector on the test set.
 - For more information, see “[2.2 Setting Up the TSC 5120A or 5115A](#)” on page 7.
2. Use one of the following methods:
 - Press **Start** on the front panel.
 - Right-click the current plot or table and select **Control > Start** from the menu.



Note

Do not bump, vibrate, or otherwise disturb the test set or the signal cables during operation, as this may influence the accuracy of data collection and results.

- The action field displays *Initializing* and then transitions to *Collecting*. See “[3.2.1 Collecting State](#)” on page 13 for details.
- Data can be collected indefinitely. The Allan deviation plot and table display values for averaging times up to 400,000 seconds.
- The instrument automatically turns off its LCD back-light if no buttons are pressed within 1 hour. Press any softkey or move the mouse to view the last displayed screen.

To stop data collection:

- Use one of the following methods:
 - Press **Stop** on the front panel.
 - Right-click the current plot or table and select **Control > Stop** from the menu.
 - The instrument stops collecting data, but continues to display the data it collected on the screen. The collecting state returns to *Ready*.



Note

The most recent data is retained on all screens until a new data collection starts or the instrument is powered off.

6.2 Printing

When the **Print** button on the front panel is pressed, the test set prints the visible plot or table to the current print job destination. See “[4.1.3 Printer Configuration](#)” on page 26 for more information about the print destinations and formats.

To print data:

1. Navigate to the data set to be printed (see “[3.1.1 Navigation](#)” on page 12).
2. Use one of the following methods:
 - Press **Print** on the front panel.
 - Right-click the current plot or table and select **Control > Print** from the menu.



Note

The test set can queue up to 15 print jobs. All print jobs will go to the currently selected printer (or file system). The number of pending print jobs is displayed in the top left corner of screen.

To cancel pending print jobs:

1. Access the **Settings** page (see “[4.1 The Settings Screen](#)” on page 21 for details).
2. Press **Printing**.
3. Press the down arrow softkey until *Cancel Print Jobs* button is highlighted.
 - The softkey interface displays a **PUSH** softkey
4. Press **PUSH** to push the *Cancel Print Jobs* button.
5. Press **Return** to return to the previous screens.

6.3 Taking or Yielding Local Control.

Please see “3.2.3 User in Control” on page 14 for an introduction about the user in control of the test set.

To take *Local* control of the test set:

1. Perform an operation that requires control. **Start** or **Stop** data collection for example.
 - The reminder dialog stating that local control of the test set is required offers the opportunity to take local control.
2. Press **Yes** to take local control.
 - Now that the test set is under *Local* control, any function that requires control can be executed using the softkey interface, mouse or keyboard.

To yield *Local* control of the test set:

1. Access the **Settings** page (see “4.1 The Settings Screen” on page 21 for details).
2. Press **Network**.
3. Press the down arrow softkey until a push button on the row labeled *Operations* has focus (denoted by a white rectangle).
 - The softkey interface displays a **PUSH** softkey.
4. Press the right arrow softkey until the *Yield Control* button is focused.
5. Press **PUSH** to push the *Yield Control* button.
6. Press **Return** to return to the previous screens.



Note

Yielding control is not strictly necessary. A *Remote* user can take control.

7: Collecting and Viewing Data Remotely

The TSC 5120A and 5115A can be controlled remotely using an Ethernet connection. Data can also be downloaded over the Ethernet connection.

Two types of connections are accepted:

- Data port connections
- Command port connections

The data port continually publishes phase difference measurements in cycles while the test set is in the *Collecting* state. See “7.3 The Network Data Port” on page 66 for additional details.

Command port connections are used to remotely control the unit to:

- Take or yield remote control of the unit (see [page 57](#))
- Start and stop collecting data (see [page 57](#))
- Retrieve or print any other data set including:
 - $\mathcal{L}(f)$ Phase Noise
 - Allan Deviation
 - One Second Phase Difference
 - One Second Frequency Difference
 - Frequency Counter Data
 - See “7.2.3 Retrieving Data from Command Port” on page 58 and “7.2.4 Printing from the Command Port” on page 59 for details.
- Configure Data Sets
 - Pause and resume updates to phase and frequency difference (see [page 60](#)) and removing the linear trend (see [page 60](#))
 - Set Allan deviation τ_0 value (see [page 61](#))
 - Configure the frequency counter’s reference frequency (see [page 61](#))
- Retrieve status information including: (see [page 62](#))
 - The input and reference signals’ frequency and power
 - The current collecting state
- Set the User Specified Title (see [page 62](#))
- Retrieve version information (see [page 62](#))

7.1 Accessing the 5120A or 5115A Remotely and Exiting the Remote Session

Before Ethernet connections to either the command or the data port can be made, their port numbers and the test set's IP address must be known. See “[4.1.2 Network Configuration](#)” on page 23 to learn how to configure them or check their current values.

Once the test set is configured and connected to the network, it can be accessed remotely using a connection program, such as Telnet. The command port accepts a single connection, while the data port accepts up to five simultaneous connections.

To access the test set remotely:

1. From a command prompt or your Telnet software, enter:

```
telnet <IP address> <1299>
```

```
telnet <IP address> <1298>
```

- This opens Telnet sessions to both ports so the instrument can be controlled and phase difference data viewed.
 - If data collection is in progress, the data port connection displays phase difference data as described in section “[7.3 The Network Data Port](#)” on page 66. If data collection must be started, see “[7.2.2 Starting and Stopping Data Collection](#)” on page 57.
2. The command port outputs a short welcome message and displays a prompt with the test set's IP address. All commands described in the following sections are entered at this prompt. Many commands produce output before re-displaying the prompt.
 3. To close the command port connection, enter:

```
quit
```

If there are multiple test sets on your network, it may be beneficial to the system administrator to know the MAC (hardware) address of each instrument. To obtain this address send the **show mac** command. The test set will respond with its unique hardware address. The settings screen shown in [Figure 8 on page 21](#) can also be used to determine the MAC address.

7.2 The Network Command Port

7.2.1 Taking or Yielding *Remote* Control

Please see “[3.2.3 User in Control](#)” on page 14 to understand the intent and effects of these commands.

Some functions such as starting and stopping data collection require that the *Remote* user has (or takes) control of the test set. When such commands are issued while the *Local* user has control, they result in an error message asking the *Remote* user take control. Once control has been taken, the command must be reissued.

To take *Remote* control of the test set:

1. Enter:

control take

From now on the *Local* user will be told that a network user is in control when they attempt operations that require it. The *Local* user will receive this message even after the *Remote* user disconnects.

To yield *Remote* control of the test set:

1. Enter:

control yield

7.2.2 Starting and Stopping Data Collection

Using the Ethernet port and a Telnet-capable program, data collection can be started and stopped remotely.

To start and stop data collection remotely:

1. Access the Command port.
 - See “[7.1 Accessing the 5120A or 5115A Remotely and Exiting the Remote Session](#)” on page 56 for more information.
2. From the Command port Telnet session, enter:
start
 - This command requires *Remote* control of the unit (see [page 57](#)).
 - When the test set reaches the *Collecting* state phase difference begins to arrive on any open data port connections (see [page 66](#)).
3. To stop data collection, enter:
stop
 - This is a good time to permit either *Local* or *Remote* use by others using the **control yield** command (though control can be yielded at any time - see [page 57](#)).

7.2.3 Retrieving Data from Command Port

All the data sets presented by the graphical user interface are available on the command port. To retrieve a data set use the **show** command followed by the data set name of interest.

To retrieve any data set on the command port:

1. Access the Command port (see [page 56](#)).
2. Start data collection if necessary (see [page 57](#)).
3. At the command prompt enter:

show <datasetname>

- where <datasetname> is one of those listed below
- The data sets returned contain the most recent data (unless they are paused). Running the same **show <datasetname>** command at a later time will return the most recent data set at that point in time.

Use the **show spectrum** command to retrieve the $\mathcal{L}(f)$ phase noise data collected thus far. The command returns a header labeling the first column as the offset frequency coordinate and second as its power spectral density. It then returns the same measurements that are plotted, one per line, with frequency in Hz followed by the power spectral density in dBc/Hz.

Use the **show spurs** command to retrieve the spur table. The command returns a header labeling the columns, then the spurs, one per line. Each line includes the spur's index and its frequency and power.

Use the **show ipn** command to retrieve the integrated phase noise table.

Use the **show adev** command to retrieve the Allan deviation. The test set outputs an Allan deviation table for each τ_0 for which it is computed. Each table is prefixed with the τ_0 value and the input filter's noise equivalent bandwidth. When all tables have been returned, the command prompt is displayed again.

Use the **show phasediff** command to retrieve the one second phase difference strip chart data. The test set outputs a header. The header indicates if the phase difference data set is paused. If the linear trend is removed, the header states so and includes the trend's slope and y-intercept. All phase difference measurements are output with their corresponding x-coordinate so the measurement can be related to the linear trend's y-intercept. For more information about linear trend removal see "[5.3.2 Removing the Linear Trend](#)" on page 43.

Use the **show freqdiff** command to retrieve the one second frequency difference strip chart data. The test set outputs a header showing that frequency difference data follows. If the frequency difference data set is paused, the header will indicate this.

Use the **show fcounter** command to retrieve frequency counter data. The command outputs a header showing the Reference frequency (and how it was set), followed by labels for the averaging interval and average frequency columns. One line per averaging interval available at this time is returned.

7.2.4 Printing from the Command Port

All data collected by the TSC 5120A or 5115A can be printed from the command port.

The **print** command can be used as a standalone command. When used without a parameter the screen currently displayed by the graphical user interface is printed. The command is more useful when used with parameters that specify what to print.

To retrieve a list of the data sets and screens that can be printed, issue the **show screens** command. The test set returns a list of print command parameters, one per line each followed by a short description of what will be printed. The following is a summary of these parameters:

spectplot - Phase Noise Plot

ipn - Integrated Phase Noise Table

spurtable - Spur Table

adevplot - Allan Deviation Plot (please see note at the end of this section)

adevtable - Allan Deviation Table (please see note at the end of this section)

phasediff - Phase Difference Plot

freqdiff - Frequency Difference Plot

fcounter - Frequency Counter Table

settings - The Settings screen

all - All of the above except settings screen (please see the note at end of this section)

The following commands would print the phase noise plot and the spur table:

print spectplot

print spurtable

Both data sets can be printed with this command:

print spectplot spurtable

Both variations ultimately print the same data sets. Issuing the print command once for each set results in two print jobs with one page each, while listing both sets in a single command produces a single print job with two pages. The second variation is more efficient because fonts must be sent to the printer (or stored in a file) only once instead of twice. When printing to a file the second variation also has the benefit of bundling the related data sets in a single file that can be viewed with third party software. The **print all** command creates a single job with all data sets.

Data sets can only be printed once per print command:

print spectplot spectplot spurtable

Does not result in a print job that prints the phase noise plot twice. Neither does the following:

print all spectplot

The print command is also used to cancel all pending print jobs. To cancel print jobs, enter:

print cancel



Note

The Allan deviation data printed corresponds to the current τ_0 value. See “[7.2.6.3 Setting the Allan Deviation \$\tau_0\$ Value](#)” on page 61 for information on setting τ_0 on a command connection.

7.2.5 Printer Configuration from the Command Port

Current printing options can be examined and modified from the command port. This section explains how to make the settings with little regard to their effects. For more information about printer setup in general see “[4.1.3 Printer Configuration](#)” on page 26.

You can retrieve the current printer configuration using the **show printoptions** command. The command returns the current print job destination and selected print format.

The print format is changed using the **set** command as follows:

```
set print format <formatname>
```

where <formatname> is one of the possible formats returned by the **show printformats** command. The valid <formatname> values are: **pcl5** and **postscript**. To print in postscript format enter:

```
set print format postscript
```

To change where print jobs are sent, use the following variations of the **set print** command:

```
set print local
```

```
set print file
```

```
set print remote <hostaddr> <port>
```

These commands change print job destination to that indicated by their last parameter.

The last variation requires IP address and port number of a network printer that supports direct transfer of information to the port, such as the HP JetDirect using port 9100. Other spooling protocols such as the Internet Printing Protocol (IPP) are not supported at this time.

7.2.6 Configuring Data Sets from the Command Port

7.2.6.1 Pausing and Resuming Phase and Frequency Difference

The phase and frequency difference display can be paused using the command port connection. When a data set is paused new measurements are recorded but not returned by the corresponding **show** command or plotted by the user interface.

Use the **pause** command as follows:

```
pause phasediff (to pause updates to the one second phase difference data set)
```

```
pause freqdiff (to pause updates to the one second frequency difference data set)
```

To resume updates, issue the **resume** command with the same parameter value passed with **pause** command. The **show** command will now return the current data set, and the user interface will plot it.

7.2.6.2 Removing the Linear Trend

The phase difference cache supports measuring and removal of its linear trend. See “[5.3.2 Removing the Linear Trend](#)” on page 43 for conceptual details.

You can perform both functions on a command connection using the following commands:

```
measurelinear (to measure the current linear trend)
```

```
removelinear <on|off>
```

The on or off parameters to the **removelinear** command are equivalent to the **Remove Linear** and **Don't Remove Linear** softkeys in the graphical user interface. Note that this command affects the plot in the graphical user interface.

The **measurelinear** command can be run regardless of whether the trend is currently removed or not. The command may result in a message stating that there is no data to measure a trend with, if the one second phase difference strip chart cache is empty at the time you issue the command.

7.2.6.3 Setting the Allan Deviation τ_0 Value

You can set the τ_0 value using the following command:

```
set tau0 <value>
```

where the <value> parameter is specified:

- as a fixed floating point number
- in seconds, as one of **0.001**, **0.01**, **0.1**, or **1**

The Allan deviation plot or table can be printed for a single τ_0 value only. To print the Allan deviation plot for a τ_0 of 10 ms, issue the following commands:

```
set tau0 0.01
```

```
print adevplot
```

For more information about printing from the network, see “[7.2.4 Printing from the Command Port](#)” on page 59.

To determine the current τ_0 value, use the **show tau0** command. The test set will return the current value in the format used by the **set tau0** command.

7.2.6.4 Setting Frequency Counter's Reference Frequency

See “[5.5 Configuring the Frequency Counter](#)” on page 47 for general information about the frequency counter.

To automatically set the reference frequency each time data collection starts, enter:

```
set referencefreq auto
```

To manually set it to a more precise value, provide the frequency in MHz as the last parameter to the set referencefreq command. To set it to 5.0000003 MHz enter:

```
set referencefreq 5.0000003
```

Future **show fcounter** commands return the averages calculated using the new reference frequency. The user interface table is also updated immediately. Note that **show fcounter** can be used to determine what the current reference frequency is.

7.2.7 Retrieving Status Information

To determine the current data collection state, enter **show state**. The command outputs the current state. If the test set is in the *Collecting* state when the command is issued, the duration of data collection is also output. For general information see “3.2.1 Collecting State” on page 13.

To see the input frequency and power of the signals attached to the test set, enter **show inputs**. The test set responds with two sets of frequency and amplitude values for the signals connected to input and reference port:

- Frequency and amplitude of the currently connected signals
- Frequency and amplitude of the signals against which the most recent (or current) data collection was run.

7.2.8 Setting the User Specified Title

For general information about the user specified title see “3.2.4 User Specified Title” on page 14.

To retrieve the current user specified title, access the command port and run the **show title** command.

To set the title that appears at the bottom of all printouts, use the **set title** command with a quoted string of up to 34 characters. The title common to many of the screen shots in this manual is set as follows:

set title “Quartz Oscillator vs Self”

The test set will return a confirmation message showing what the title has been set to. This provides immediate feedback in case the string you provided is truncated because it exceeds the maximum length.

7.2.9 Showing the Software Version

Version information, useful for troubleshooting, can be accessed on the command port.

To remotely show the software version:

1. Access the Command port (see [page 56](#)).
2. At the command prompt enter:

show version

- The commands returns information such as the following:
 - *Model: TSC 5115A*
 - *DSP CPLD Revs: 03 00 00 00*
 - *ADC CPLD Revs: 01 01 00 00*
 - *Software: Revision 252*
 - *Options:*
 - *DOCSIS ATP*

7.2.10 Viewing Help for Remote Commands

The test set continues to be under development and new commands may have been added to the command line interface. The help command provides a list of all available commands.

To view a list of all available commands:

1. Access the Command port.
 - For more information, see [“7.1 Accessing the 5120A or 5115A Remotely and Exiting the Remote Session”](#) on page 56.
2. From the Command port Telnet session, enter:
help
 - A list of all the available commands displays.

To view help for a specific command:

1. Access the Command port.
 - For more information, see [“7.1 Accessing the 5120A or 5115A Remotely and Exiting the Remote Session”](#) on page 56.
2. From the Command port Telnet session, enter:
help <command_name>
 - The usage of the command displays.



Note

This variation of the **help** command also lists various abbreviations for some verbose commands. Issuing **help measurelinear** reveals that **ml** is a valid shorthand for the command.

Commands validate their parameters and in most cases provide a list of valid parameters if arguments are found to be invalid. This too can serve as a source of help using a command.

7.2.11 Other Commands

The following lists some commands that were not documented in detail. Please use the **help** network command as the authoritative source for all commands. See [“7.2.10 Viewing Help for Remote Commands”](#) on page 63 for details.

reset

Reset the test set.

restorefactorydefaults

Restores all persistent settings to factory default values and reboots the test set. See [“4.1.5 Restoring Factory Default Settings”](#) on page 28 for more information about persistent settings.

set <option> <args>

date options:

set date YYYYMMDDhhmmss

set dateformat <1|2|3> - sets date format for printouts.

1 = verbose (three letter month name)

2 = numeric date, month first (mm/dd/yyyy)

3 = numeric date, day first (dd/mm/yyyy)

set timeformat <24|12> - sets time format for printouts.

24 = 24 hour format

12 = 12 hour format with AM/PM specifier

show <option>

date - returns the current date in the configured format.

dateformat - current date and time format.

timeformat - current date and time format.

7.2.12 Command Summary

Command	Synopsis
beep	Beeps the pc speaker
button	Simulates a front panel button press.
control	Takes or yields remote control of the test set.
help	Display help for a command, or list all commands.
history	Lists previously entered commands.
measurelinear	Measures linear trend in 'show phasediff' data set.
pause	Pauses updates on phase or frequency difference cache.
print	Prints a plot or table.
prompt	Turns command prompt on or off.
quit	Closes the command connection.
removelinear	Enables/Disables phase difference linear trend removal.
reset	Resets the test set.
restorefactorydefaults	Restores all configuration settings to factor default settings.
resume	Resumes updates to phase or frequency difference cache.
set date <YYYYMMDDhhmmss>	Sets system date and time
set dateformat <1 2 3>	Selects format for printout date stamps.
set print file	Print new jobs to the file system (fetch print jobs using FTP).
set print format <format>	Print new jobs in the specified format
set print local	Print new jobs to local (USB) printer.

Command	Synopsis
set print remote <host> <port>	Print new jobs to network printer.
set referencefreq <auto/freq>	Selects automatic, or specified manual reference frequency used by frequency counter.
set tau0 <tau0value>	Sets tau0 value in seconds: 0.001, 0.01, 0.1 or 1
set timeformat <24/12>	Selects time format for printout time stamps.
set title <title>	Sets user specified title (quoted string up to 34 characters)
show adev	Returns snapshot of Allan deviation tables.
show date	Returns current date and time in selected format
show dateformat	Returns selected printout date stamp format
show fcounter	Returns snapshot of frequency counter table.
show freqdiff	Returns snapshot of frequency difference strip chart.
show inputs	Returns input frequency and amplitude on input signal ports.
show ipn	Returns integrated phase noise table.
show mac	Returns MAC (ethernet) address of the test set.
show phasediff	Returns snapshot of phase difference strip chart.
show printformats	Returns acceptable values for <i>set print format</i> command
show printoptions	Returns current printer settings.
show screens	Returns name of screens that can be printed.
show spectrum	Returns snapshot of spectrum table.
show spurs	Returns snapshot of spur table.
show state	Returns current collecting state.
show tau0	Returns current tau0 value.
show timeformat	Returns selected printout time stamp format.
show title	Returns current user specified title.
show version	Returns model, software and hardware version information.
start	Begin data collection
stop	Stop data collection.

7.3 The Network Data Port

The network data port outputs phase difference data while the test set is in the *Collecting* state. The phase differences are in units of cycles of the Input signal. Phase differences are output as floating point numbers, one number per line, 1000 each second.

The data port accepts no input, all input to data port connections is discarded by the TSC 5120A or 5115A.

Phase difference measurements are published while the test set is in the *Collecting* state. See “[3.2.1 Collecting State](#)” on page 13. When data collection is stopped or the test set is in the *Initializing* state, no data is published. Once collection is restarted, phase differences are output again. This means that a data port connection can be kept open while collection is stopped, input or reference signal sources are changed, and collection is restarted.

To retrieve phase difference data remotely:

1. Access the Data port.
 - For more information, see “[7.1 Accessing the 5120A or 5115A Remotely and Exiting the Remote Session](#)” on page 56.
 - If you want to store the data in a file, tell your Telnet software to capture the data.
 - If no phase difference data is published on the command port, the test set is not in the *Collecting* state - connect to the command port and start data collection. See “[7.2.2 Starting and Stopping Data Collection](#)” on page 57 for details.

8: Optional Functionality

The TSC 5120A and 5115A can be purchased with optional functionality. Some options are included with one or the other type of test set. This chapter describes available options.

8.1 DOCSIS

8.1.1 DOCSIS Overview

DOCSIS stands for “Data Over Cable Service Interface Specification”. Test sets with the DOCSIS option enabled can be used to easily test jitter for cable modems and supporting equipment. The goal of these tests is to ensure that the master clock and symbol clock are properly locked via the M/N ratios as per the DRFI Specification Section 6.3.6. The DOCSIS option is included with the TSC 5115A and the 5120A.

The test works on the assumption that locking between the master clock and the symbol clock may be verified by comparing the master clock from a DTI server test port to that of the symbol clock from the EQAM RF output in alternating binary sequence mode. All measurements must be performed with worst case common mode noise on the DTI client input from the DTI server. The test run by the option covers 100% of the locking parameters on a single channel or the single test port. Other channels are assumed to behave in the same manner.

The jitter calculation uses frequency counter’s reference frequency, 100 second frequency average, integrated phase noise with a low limit of 1 mHz and the user supplied DRFI ratio as inputs. It computes jitter resulting from frequency error ($J1$) and jitter resulting from random variations ($J2$), and finally combines those values to compute *Total Jitter*.

The following table explains in detail how *Total Jitter* is calculated.

Value	Units	Definition or Calculation	Notes
M		DRFI specification ratio numerator	see step 3 below
N		DRFI specification ratio denominator	see step 3 below
reference_frequency	Hz	reference frequency	see step 4 below
desired_freq	Hz	$M / N * \text{reference_frequency}$	
meas_freq	Hz	measured input frequency	100 s frequency average
meas_random_jitter_RMS	radians	$\Phi_{\text{RMS}}(1 \text{ mHz})$	integrated phase noise
con	s	$50 / \text{SQRT}(3)$	constant
J1	ns	$\text{con} * \text{meas_freq} - \text{desired_freq} / \text{desired_freq}$	jitter from frequency error
J2	ns	$\text{meas_random_jitter_RMS} / (2 * \Pi * \text{desired_freq})$	jitter from random variations
Total Jitter	ns	$\text{SQRT}(J1^2 + J2^2)$	pass/fail criterion

8.1.2 Using the DOCSIS Option Locally

Figure 17 shows the DOCSIS option screen after it has calculated total jitter for a set of input signals. The signals *PASSED* because total jitter was less than 1.5 ns.

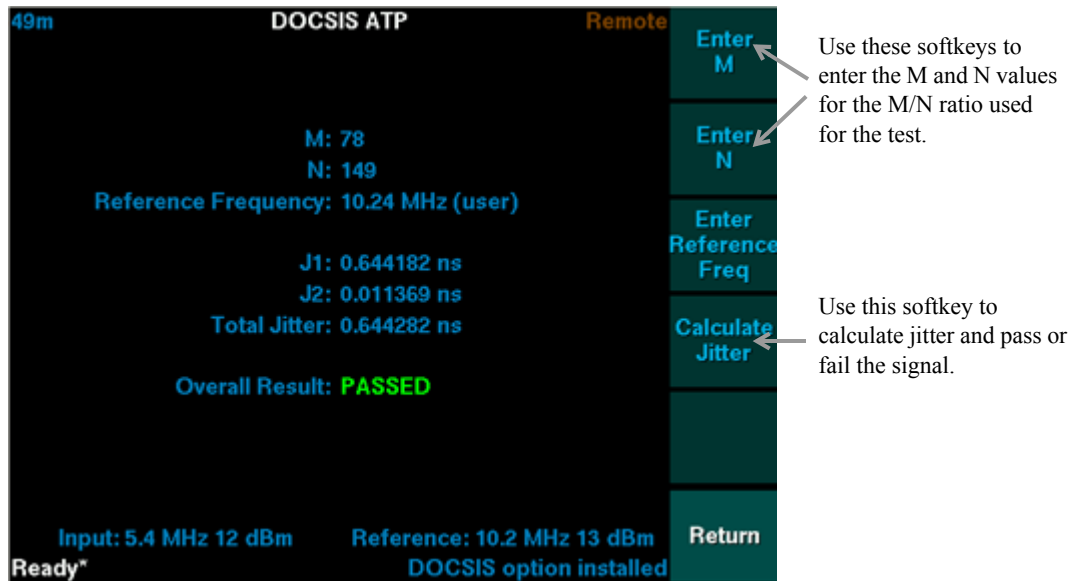


Figure 17: DOCSIS Option Screen

To run a DOCSIS test:

1. Connect the master clock to the *Reference* port and the bit clock to the *Input* port.
 - Verify that the *Reference* frequency displays as 10.2 MHz and the *Input* frequency displays as 5.x MHz.
2. Press **Settings and Options**, then **Options** and finally **DOCSIS ATP** to navigate to the DOCSIS option screen.
3. Press **Enter M** to enter the numerator and **Enter N** for the denominator.
 - See “3.4.1.1 The Number Pad Editor” on page 17 for help with entering numbers.
 - Both *M* and *N* must be positive integers representable as an unsigned 16 bit value.
 - These values persist when the test set is powered off.
4. Press **Enter Reference Freq** and enter the frequency counter’s reference frequency.
5. Press **Start** and collect data for at least 45 minutes.
6. Press **Calculate Jitter**.
 - If a dialog stating that more data must be collected is displayed, press **Dismiss Dialog**, wait a few minutes, then press **Calculate Jitter** again.
 - The *J1*, *J2* and *Total Jitter* values are calculated and displayed, the *Overall Result* shows *PASSED* when jitter is less than 1.5 ns or *FAILED* otherwise.



Note

The DOCSIS and frequency counter reference frequency are the same value. Changing the reference frequency in either screen changes the setting for both screens.

8.1.3 Using the DOCSIS Option Remotely

The DOCSIS option can be utilized on the network command port. See “[7: Collecting and Viewing Data Remotely](#)” on page 55 for details about controlling the test set using a network connection.

To run a DOCSIS test remotely:

1. Connect the master clock to the *Reference* port and the bit clock to the *Input* port.
2. Access the Command port. See “[7.1 Accessing the 5120A or 5115A Remotely and Exiting the Remote Session](#)” on page 56.
3. Use the **show inputs** command to verify that the reference frequency is at 10.2 MHz and the input frequency is at 5.x MHz.
4. Issue the **start** command and collect data for at least 45 minutes.



Note

The start command requires remote control of the test set. See “[7.2.1 Taking or Yielding Remote Control](#)” on page 57 for more information.

5. Use the **set referencefreq** command to set the reference frequency if necessary.
 - See “[7.2.6.4 Setting Frequency Counter’s Reference Frequency](#)” on page 61 for details.
 - Once the reference frequency has been set it persists until it is changed by the user.
6. Use the **docsis** command to calculate jitter.
 - The **docsis** command has two variations, they are explained in the example below.
 - The command returns the *J1*, *J2*, *Total Jitter* and *Overall Result* values. The user interface reports the same values.
 - If the command returns an error message stating that more data must be collected before the test can be run, wait for more data to be collected and reissue the **docsis** command.

The **docsis** network command has two variations. One variation accepts the *M* and *N* parameters to be used for jitter calculation. The other variation reuses the *M* and *N* values from the most recent DOCSIS test. To run the test depicted in [Figure 17](#) on page 68, enter the following commands once enough data has been collected:

```
set referencefreq 10.24
```

```
docsis 78 149
```

Once *M* and *N* values have been set as parameters to the **docsis** network command or in the user interface, they can be reused by omitting the parameters from the command. To use current *M*, *N* and reference frequency values for the test simply enter:

```
docsis
```


9: Maintaining the TSC 5120A or 5115A

9.1 Calibrating the 5120A or 5115A

Timing Solutions Corporation can provide a manufacturer's calibration.

A performance verification procedure is available from Timing Solutions Corporation.

Contact sales@timing.com for pricing or to obtain the performance verification procedure.

9.2 Cleaning the 5120A or 5115A



Warning

Do not spray or use too much liquid when cleaning the unit. Liquid can enter the unit and damage sensitive electronic components.

Clean the main chassis with a soft cloth dampened with a mild soap and water solution.

10: Troubleshooting the 5120A or 5115A

Perform all of the following procedures before returning the test set for service. If the test set still appears to have a problem, call Timing Solutions Corporation (TSC) and request technical support. Have the serial number of your instrument ready to provide to a technical representative.



Caution

Do not remove the top cover of the instrument. It does not contain any user-serviceable parts. The 3 V lithium battery and memory card on the single board computer PCB must be replaced only by trained and authorized personnel.

The only user-serviceable parts are the fuses. For more information, see “[10.2 Replacing Fuses](#)” on page 76.

If the test set does not appear to be operating properly, check the following first:

1. If the test set is turned on, press **Power** to turn it off.
2. Check for visible damage on the unit, cables, and connectors.
3. Ensure that all cables are firmly connected.
4. Determine if any input power circuit breakers have been tripped.
5. Ensure that your power source is within specification.
6. Press **Power** to turn the instrument on.
7. Check that the green LED on the front panel near the **Power** button is lit.
 - If it does not come on and your power source has been thoroughly checked, unplug the instrument from its power source and check both fuses mounted in the power entry module located on the rear of the chassis. Replace if necessary with 250-volt, 1-amp, time delay, 5 x 20 mm fuses. For more information, see “[10.2 Replacing Fuses](#)” on page 76. Check your power source prior to reconnecting the power cord after replacing fuses.
 - The Timing Solutions logo is displayed.
 - If the “Self test has failed for the following item(s)...” message displays during start-up, contact a TSC service representative.
8. Connect signals to the *Input* and *Reference* ports.
 - Verify that both signals are within operating range. See “[3.2.2 Input Signals’ Frequency and Power](#)” on page 13 for more information.
9. Press **Start**.
 - The test set should begin collecting data, as described in “[2.2.1 Turning On the 5120A or 5115A](#)” on page 9, and should update the data display.

10.1 Troubleshooting Error Messages

Table 2 lists the error messages that display in the action field, their meaning, and what to do.

Table 2: Error messages

Error message	What it means	What to do
Cannot start collecting while input signals' frequency or amplitude are out of operable range.	Data collection cannot start if the input signals fall below 1 MHz or 3 dBm, or go above 30.0 MHz or 17 dBm.	Check the frequency and amplitude of the highlighted input
Input/Reference frequency/amplitude changed significantly. Stopped Collecting.	The specified signal's frequency or amplitude changed significantly from the values at the time data collection was started. Collection was stopped automatically as not to corrupt data sets computed thus far.	<ol style="list-style-type: none"> 1. Check the signal connections on the input and reference ports. 2. Do not bump or otherwise disturb the test set or the connected signals. 3. Do not change the input or reference port signals' frequency during data collection. 4. If the problem persists, contact a Timing Solutions representative.
Input/Reference ADC clipping error. Stopped Collecting.	The test set did not properly set attenuators to correctly limit input voltage to the range the ADC can measure.	<ol style="list-style-type: none"> 1. Check the signal connections on the input and reference ports. If they are within operating range, cycle power. 2. Do not bump or otherwise disturb the test set or the connected signals. 3. Do not change the input or reference port signals' amplitude during data collection. 4. Contact a timing solutions representative if the problem persists.
Failed to connect to printer <ip address>. (where <ip address> denotes the address of the target network printer)	A connection could not be established to the specified remote printer due to a network discontinuity or the printer not being powered on.	<ol style="list-style-type: none"> 1. Check the connection from the test set to the network. 2. Check the connection from the printer to the network. 3. Make sure the printer is powered on. 4. Make sure that you used the correct IP address and port. <ul style="list-style-type: none"> • For more information, see “4.1.3 Printer Configuration” on page 26.
Failed to connect to USB printer.	Tried to print to a local USB printer, but could not find a printer connected to the USB port. Or the printer is not powered on.	Make sure the local USB printer is connected to the USB port and powered on.

Table 2: Error messages

Error message	What it means	What to do
Failed to print entire file.	Printing stopped in the middle of transferring the information to the remote or USB printer. This is probably due to the printer being powered off or a connection discontinuity.	<ol style="list-style-type: none"> 1. Check the connection from the test set to the network or USB printer. 2. Check the connection from the printer to the network. 3. Make sure printer is powered on.
Maximum number queued print jobs reached.	Print jobs were queued faster than they can be written to the printer or file system. Up to 15 print jobs can be queued before this message is displayed.	Do not queue print jobs so quickly or attach a faster printer.
File system integrity check failed. All settings have been set to factory defaults.	The part of the file system where configuration and preferences are stored failed integrity check when the test set was powered on. It was restored to factory defaults.	<ol style="list-style-type: none"> 1. Reconfigure the test set. If this problem persists, contact a Timing Solutions Representative.
Process <processname> has failed. Please cycle power on the unit. (where <processname> is one of a2dReader, netd or ui)	One of the applications has failed at a level indicative of a programming error.	<ol style="list-style-type: none"> 1. Power cycle the test set. If this problem persists, contact a Timing Solutions Representative.
Failed to open keypad device.	The user interface was unable to communicate with front panel keypad device. This indicates a corrupt file system (driver cannot be loaded), or a broken keypad.	<ol style="list-style-type: none"> 1. Power cycle the test set. If this problem persists, contact a Timing Solutions Representative.
Detailed programming error exception error message such as: UI Initialization File: sourcecode.cc Line: 150 Errno 2: ENOENT Msg: Example error. Retadds: 0x80ff490 0x80ddb60 0x80dc0b0	The user interface was initialized enough to display dialogs. An unhandled exception reached the main event loop. Information in this dialog is useful to the software developers.	Please contact a Timing Solutions representative with all information in the error message.

10.2 Replacing Fuses

If you know that a local event caused blown fuses, you can replace the fuses in the test set power entry module on the rear panel. See “[Figure 2: Rear panel](#)” on page 5.

Required for this procedure:

- Small flat-head screwdriver
- Replacement fuse for a standard IEC 320 power entry module with fuse (250-volt, 1-amp, time delay, 5 x 20 mm fuse, T)

To replace a fuse:

1. Disconnect the power cable from the back of the test set.
2. Using a small screwdriver, open the fuse cover on the back of the test set.
3. Replace the old fuses as necessary.
4. Close the fuse cover.
5. Reconnect the power cable to the back of the test set.

Appendix A: Specifications

A.1 EC Declaration of Conformity

In accordance with EN 45014:1998

We Timing Solutions Corporation
Of 4775 Walnut Drive Suite 1B
 Boulder, CO 80301
 USA

declare that:

Equipment Phase Noise Test Set
Model Number **TSC 5120A and 5115A**
Product Options None

in accordance with the following Directives:

73/23/EEC The Low Voltage Directive
 and its amending directives

89/336/EEC The Electromagnetic Compatibility Directive
 and its amending directives

has been designed and manufactured to the following specifications:

Safety: EN61010-1: 2001
 Safety Requirements for Electrical Equipment for Measurement, Control and
 Laboratory Use - Part 1: General Requirements

EMC EN61326-1: 2001
 Electrical Requirements for Electrical Equipment for Measurement, Control and
 Laboratory Use - Part 1: General Requirements
 EN 55011 Class A
 Radiated Emissions

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all essential requirements of the Directives.

Signed by:

Name: S.R. Stein
Position: President

Done at Boulder, Colorado U.S.A on 17 January 2006

A.2 Electrical Specifications

Table 1 lists the electrical specifications for the 5120A and 5115A.

Table 1: Electrical specifications

Item	Specification
Protection Class	Class I (Grounded Type)
Power Input Voltage	100–240 V AC Note: Fluctuations not to exceed $\pm 10\%$ of nominal supply voltage.
Power Input Frequency	50–60 Hz
Power consumption	5120A - 60 W maximum 5115A - 40 W maximum
Power Inlet Type	IEC 60320 sheet C14
Power Supply Cord Set	18 AWG (0.75 mm ² minimum)
Power Mains Fuse	Two 250 V ~ 1A T (Time delay) 5 x 20 mm.
Signal Inputs	<ul style="list-style-type: none"> ■ Frequency: 1–30 MHz ■ Impedance: 50 Ω \pm 5 Ω ■ Input level: 3–17dBm
Connectors	<ul style="list-style-type: none"> ■ Input: Two TNC (supplied with BNC adapters) ■ Output: Two USB 1.1, Type A ■ Network: RJ-45 (10 or 100 baseT)
Battery	<ul style="list-style-type: none"> ■ Lithium on single board computer printed circuit board: 3V, type BR2032. ■ Dispose of the battery in accordance with local regulations.

Table 2: $\mathcal{L}(f)$ noise floor specifications¹

Input Signal	5115A Specifications	5120A Specifications
1 MHz	1 Hz offset, < -131 dBc/Hz 10 Hz offset, < -140 dBc/Hz 100 Hz offset, < -142 dBc/Hz 1,000 Hz offset, < -142 dBc/Hz 10,000 Hz offset, < -142 dBc/Hz 100,000 Hz offset, < -142 dBc/Hz	1 Hz offset, < -131 dBc/Hz 10 Hz offset, < -140 dBc/Hz 100 Hz offset, < -148 dBc/Hz 1,000 Hz offset, < -156 dBc/Hz 10,000 Hz offset, < -160 dBc/Hz 100,000 Hz offset, < -163 dBc/Hz
2-5 MHz	1 Hz offset, < -133 dBc/Hz 10 Hz offset, < -143 dBc/Hz 100 Hz offset, < -147 dBc/Hz 1,000 Hz offset, < -147 dBc/Hz 10,000 Hz offset, < -147 dBc/Hz 100,000 Hz offset, < -147 dBc/Hz	1 Hz offset, < -140 dBc/Hz 10 Hz offset, < -152 dBc/Hz 100 Hz offset, < -164 dBc/Hz 1,000 Hz offset, < -169 dBc/Hz 10,000 Hz offset, < -169 dBc/Hz 100,000 Hz offset, < -169 dBc/Hz
10 MHz	1 Hz offset, < -133 dBc/Hz 10 Hz offset, < -143 dBc/Hz 100 Hz offset, < -147 dBc/Hz 1,000 Hz offset, < -147 dBc/Hz 10,000 Hz offset, < -147 dBc/Hz 100,000 Hz offset, < -147 dBc/Hz	1 Hz offset, < -145 dBc/Hz 10 Hz offset, < -155 dBc/Hz 100 Hz offset, < -165 dBc/Hz 1,000 Hz offset, < -170 dBc/Hz 10,000 Hz offset, < -175 dBc/Hz 100,000 Hz offset, < -175 dBc/Hz
20 MHz	1 Hz offset, < -123 dBc/Hz 10 Hz offset, < -136 dBc/Hz 100 Hz offset, < -146 dBc/Hz 1,000 Hz offset, < -147 dBc/Hz 10,000 Hz offset, < -147 dBc/Hz 100,000 Hz offset, < -147 dBc/Hz	1 Hz offset, < -137 dBc/Hz 10 Hz offset, < -150 dBc/Hz 100 Hz offset, < -160 dBc/Hz 1,000 Hz offset, < -170 dBc/Hz 10,000 Hz offset, < -172 dBc/Hz 100,000 Hz offset, < -172 dBc/Hz
30 MHz	1 Hz offset, < -127 dBc/Hz 10 Hz offset, < -137 dBc/Hz 100 Hz offset, < -145 dBc/Hz 1,000 Hz offset, < -146 dBc/Hz 10,000 Hz offset, < -146 dBc/Hz 100,000 Hz offset, < -147 dBc/Hz	1 Hz offset, < -127 dBc/Hz 10 Hz offset, < -138 dBc/Hz 100 Hz offset, < -151 dBc/Hz 1,000 Hz offset, < -162 dBc/Hz 10,000 Hz offset, < -165 dBc/Hz 100,000 Hz offset, < -165 dBc/Hz

Note 1: For each 1dB decrease in input amplitude below 8 dBm, the noise floor will increase approximately 1dBc.

Table 3: Allan Deviation Specifications

Model	Specification
5115A	less than 1E-14 at 1 second, 0.5 Hz bandwidth
5120A	less than 3E-15 at 1 second, 0.5 Hz bandwidth

A.3 Environmental Specifications



Warning

Ordinary protection: This unit is for **INDOOR USE ONLY**. It is not sealed to prevent moisture from entering the enclosure.

- Pollution Degree 2 per EN61010-1EN 61010-1
- Installation (Over-Voltage) Category II for transient over-voltages per EN 61010-1EN 61326-1, Class A
- Equipment suitable for continuous operation

Table 4 lists the environmental specifications for the TSC 5120A and 5115A.

Table 4: Environment specifications

Item	Temperature	Relative Humidity	Altitude
In Use	15°C to 40°C	5% to 95% (non-condensing)	3,000 meters (9,843 feet)
Storage	-25°C to 70°C	5% to 95% (non-condensing)	
Transportation	-25°C to 70°C	5% to 95% (non-condensing)	

A.4 Physical Specifications

Table 5 lists the physical specifications for the TSC 5120A and 5115A.

Table 5: Physical specifications

Item	Specification
Size	33.8 cm x 17.4 cm x 43.7 cm (13.31" x 6.84" x 17.21")
Weight	5120A: Approximately 9.1 kg (20 pounds) 5115A: Approximately 8.4 kg (18.5 pounds)

Figure 1 shows the dimensions of the TSC 5120A and 5115A.

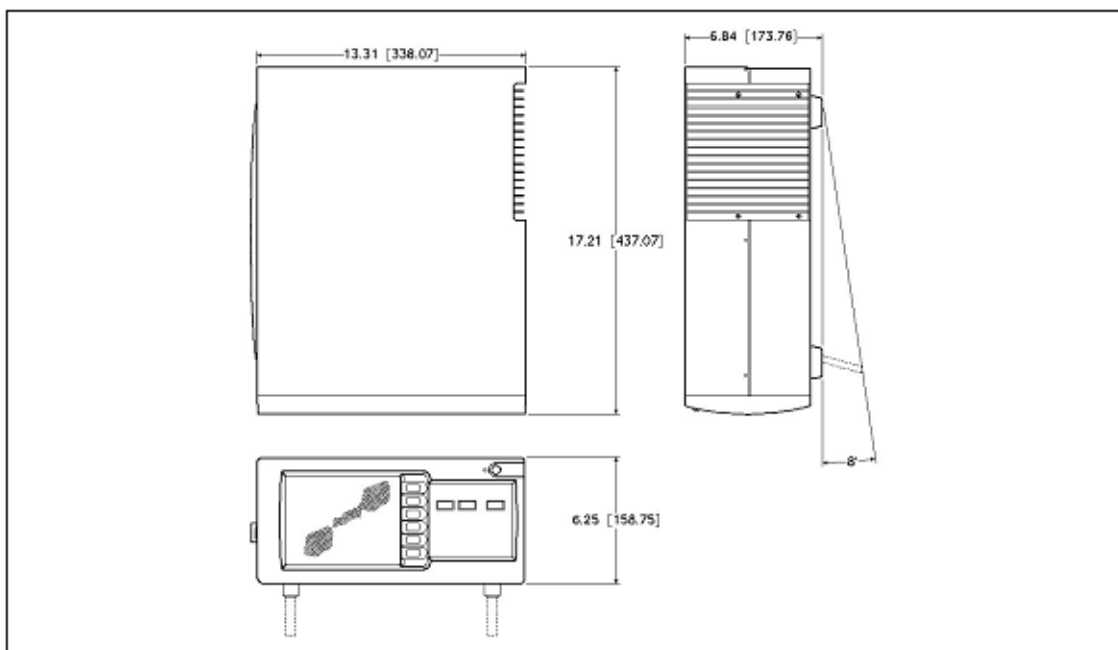


Figure 1: 5120A and 5115A dimensions

Appendix B: Theory of Operation

B.1 Introduction

Traditionally, phase noise measurements are made by analog techniques. A transducer is used to convert the phase fluctuations to a voltage that is sampled and Fourier analyzed. The transducer is almost always a double-balanced mixer that, along with the following low noise amplifiers, must be calibrated at all Fourier frequencies of interest. The double balanced mixer operates as a phase detector only when the signals at the local oscillator (LO) and signal ports are approximately in phase quadrature. Thus analog phase noise measurements of two sources require that the unit under test be phase locked to the reference. By using digital techniques, it is possible to eliminate both of these restrictions making it much simpler to make high quality phase noise measurements. Figure 1 shows the analog approach to source phase noise measurements.

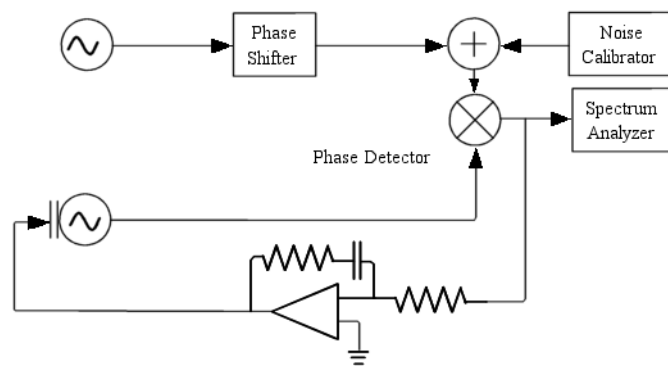


Figure 1: Analog source phase noise measurements require both calibration and a phase-lock loop.

The digital method samples the RF waveforms rather than the output of the phase detector. The phase detection is performed by digital signal processing, which results in several advantages: the phase detector has $2N\pi$ range, eliminating the need for a phase-lock loop (PLL), and all digital filters are sufficiently flat to eliminate the need to calibrate individual measurements. It is possible to make the signal processing errors fall below the noise of the analog-to-digital converters (ADCs), which then determine the noise floor of the direct-digital, phase-noise measurement system. As seen below, this noise is rather high, but can be reduced to useful levels through the application of cross correlation.¹

1. F. L. Walls, S. R. Stein, James E. Gray, and David J. Glaze, "Design Considerations in State-of-the-Art Signal Processing and Phase Noise Measurement Systems," Proceedings of the 30th Annual Frequency Control Symposium, 1976, pp 269-274.

The concept for direct-digital phase-noise measurements is shown in Figure 2.

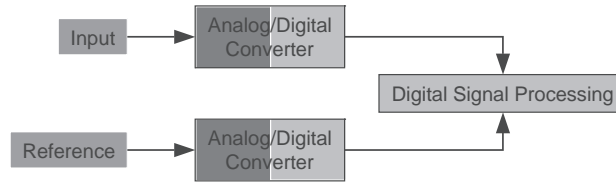


Figure 2: The RF signals are immediately converted to digital samples in order to perform direct-digital phase-noise measurements.

B.2 Theory

The analog-to-digital converters have 14 bits of precision and maximum sampling rates of 80 MHz. In order to prevent harmonics, spurs, and noise from aliasing into the measured spectrum, a 30 MHz analog anti-alias filter is employed before the RF signals are sampled. The heart of the approach is the down converter that immediately follows the sampler. In-phase samples of each input signal are multiplied by the sine and cosine of a synthesized local oscillator and low-pass filtered. When the LO frequency is approximately equal to the input frequency, the output of the filters are in-phase (I) and quadrature (Q) base-band samples. The phase difference between the input signal and the synthesized LO is computed using the arctangent function as shown in Figure 3.

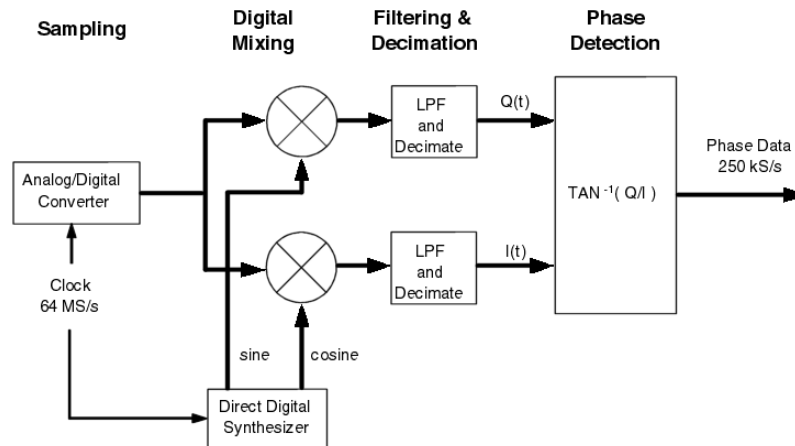


Figure 3: A local oscillator synthesized from the internal clock down-converts the input to base-band where the samples are used to compute the phase difference between the LO and the input.

This step is the heart of the direct-digital technique. It is not necessary to down-convert to DC before computing the phase difference. A small DC offset causes the phase to accumulate nearly linearly. Although the arctangent function repeats every π radians, it is possible to unwrap the phase and recover the correct linear function. This should be contrasted with the analog approach. The double balanced mixer produces a distorted sine function of the phase difference. As the two inputs approach the in-phase condition, the output of the mixer is insensitive to the phase difference between the signals, and the distortion makes it impossible to accurately compute the

phase even if quadrature mixers were employed. Thus analog test sets must be maintained near quadrature where the sine of the phase is nearly linear and equal to the phase angle. When measuring sources, the quadrature condition is achieved by a long time constant, phase-lock loop.

Down-conversion is performed on the second input channel, and the two are subtracted to obtain the phase difference between the two sources. However, if the two input signals have different nominal frequencies, then the phase of the second channel must be scaled to the same nominal frequency as the first channel. For example, if we were calculating the phase difference between a 10 MHz signal and a 5 MHz signal, then the phase difference between the 5 MHz source and the LO must be multiplied by 2 before subtraction from the phase difference of the 10 MHz signal and its LO. The subtraction process causes the phase noise of the instrument's clock oscillator to cancel, just as it does in a dual-mixer, phase-difference, measurement system.

The frequency content of the measured phase difference is analyzed by computing the Discrete Fourier Transform (DFT) of the phase difference. The computation to this point is shown in Figure 4. However, if the Power Spectral Density (PSD) of the phase were computed from the DFT, the broadband noise floor would be limited by the white noise of the ADCs at a level of -150 dBc/Hz or worse with today's best converters. This is the price that has been paid for the convenience of operation without a PLL or need for calibration and would make the direct-digital approach uninteresting for measuring precision oscillators, except for the fact that convenient methods exist to overcome the limitation.

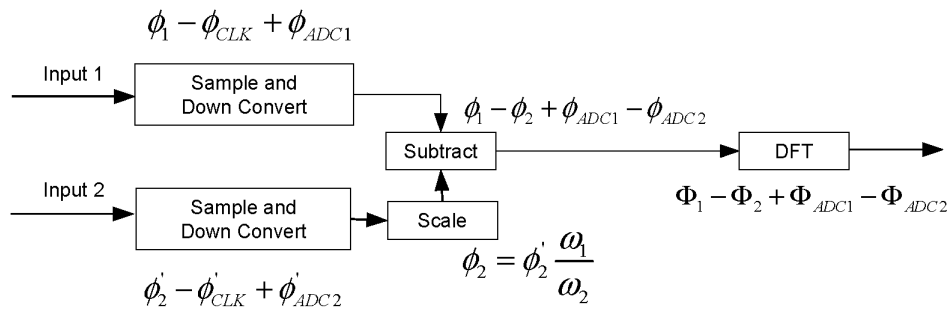


Figure 4: After down-conversion, the phase differences are scaled, subtracted, and Fourier analyzed to determine the frequency content.

The power spectral density of phase, $S_{\phi}(f)$ is the squared magnitude of the Fourier transform. This computation is performed by the TSC 5115A as shown in Figure 5. The instrument displays $\mathcal{L}(f)$, which is defined to be equal to half the spectral density.

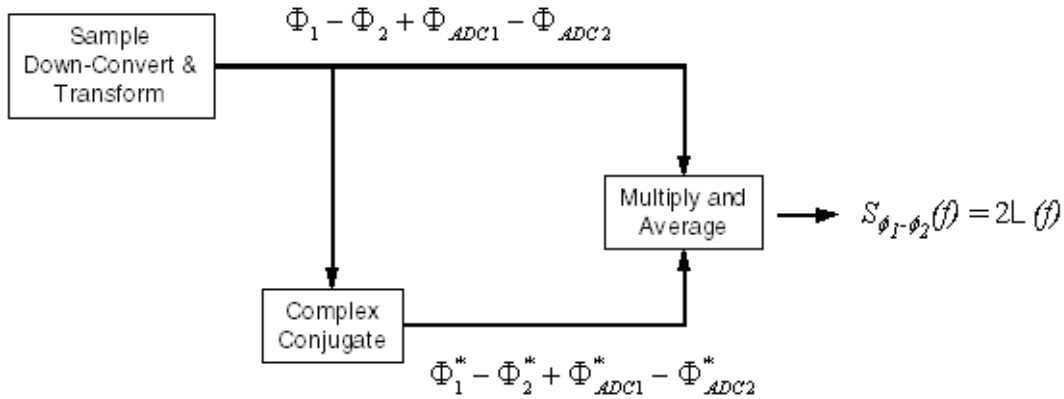


Figure 5: The power spectral density of the phase is computed by multiplying the phase by its complex conjugate and averaging (TSC 5115A)

Instead of computing the magnitude-squared of the DFT to obtain an estimate of the PSD, the TSC 5120A computes the cross spectrum of two identical measurement systems as shown in Figure 6. The ADC noise is highly uncorrelated and averages down, allowing improvement of the broadband noise floor to better than -170 dBc/Hz.

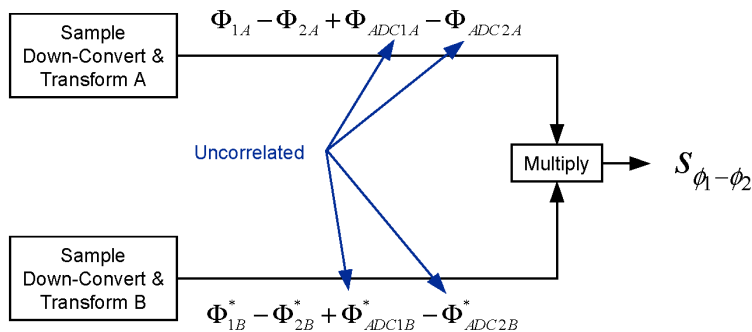


Figure 6: The PSD is computed as the cross-spectrum of the DFTs from two identical processing front ends.

Finally, in order to produce a useful PSD estimate, the spectrum estimation process is broken into a series of spans that have appropriate frequency resolution (DFT length). The process as performed by the TSC 5120A with cross correlation is shown in Figure 7. This process allows more rapid estimation of the higher frequency portions of the spectrum. Data for each lower frequency span is obtained by low-pass (anti-alias) filtering the higher sample rate data, then decimating it appropriately.

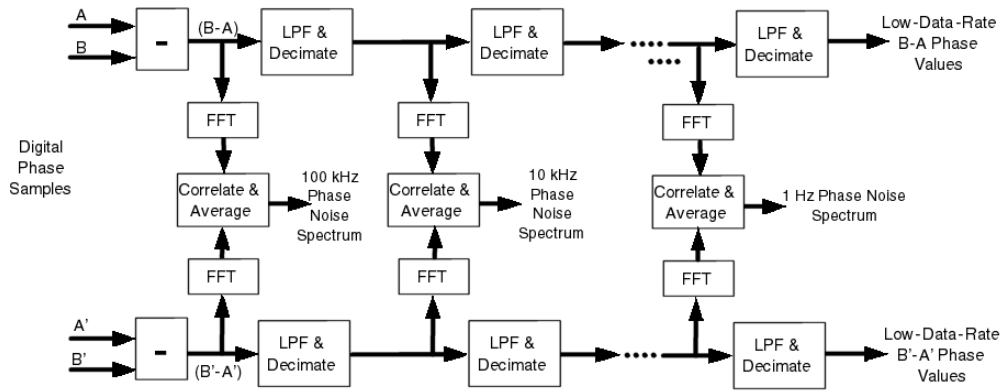


Figure 7: Successive filter-decimate-transform signal processing stages

B.3 Measurement Methodology

All phase noise measurements are referenced to the frequency of the Input port. This has an effect on how you connect the instrument for different measurements. One example is listed below.

Example: You have a noisy synthesizer tuned to 12 MHz and a very clean 5 MHz reference. You want to know the phase noise of the synthesizer.

- Test Method 1—You connect the 12 MHz signal to Input and the 5 MHz signal to Reference. The phase noise of the synthesizer under test will be measured and displayed relative to 12 MHz.
- Test Method 2—You connect the 5 MHz signal to Input and the 12 MHz signal to Reference. The phase noise of the synthesizer will be measured and displayed referenced to the 5 MHz signal. To make the phase noise measurements referenced to 12 MHz, you will need to add a frequency scaling term of $20 \cdot \log_{10}(f(\text{INPUT})/f(\text{REFERENCE})) = 20 \cdot \log_{10}(12\text{MHz}/5\text{MHz}) = 7.60 \text{ dB}$ to all phase noise measurements displayed. You will do this scaling with a separate tool.

Glossary

\n	Line feed
\r	Carriage return
dB	decibels
dBc	Decibels referred to the carrier
dBc/Hz	Decibels per Hz referenced to the carrier
CPLD	Complex Programmable Logic Device
DHCP	Dynamic Host Configuration Protocol
DOCSIS	Data Over Cable Service Interface Specification
DRFI	Downstream RF Interface
DSP	Digital Signal Processor
DTI	DOCSIS Timing Interface
DUT	device under test
EQAM	Edge Quadrature Amplitude Modulation
ESD	electrostatic discharge
FTP	File Transfer Protocol
IPP	Internet Printing Protocol
NEQBW	Noise equivalent bandwidth
PCL	Printer Control Language
SSB	single side band
TSC	Timing Solutions Corporation
USB	Universal Serial Bus

Index

Numerics

- 5120A, 5115A
 - overview 4
 - theory of operation 83
 - unpacking 8

A

- Allan Deviation
 - scaling plot 40
 - selecting τ_0 locally 41
 - selecting τ_0 remotely 61
 - specifications 79
 - test mask 41
 - viewing table 41
- automatic reference frequency - see frequency counter

C

- cables
 - required 7
- calibrating 71
- cancel printing - see printing
- cleaning 71
- commands
 - viewing help for remote 63
 - viewing list of remote 63
- Conformity, declaration of 77
- connecting
 - power 7
 - to the Ethernet port 7
 - to the USB ports 7
- connections
 - Ethernet 5
 - input signals 4
 - power 5
 - USB 5
- control
 - take or yield local control 53
 - take or yield remote control 57
 - user in control defined 14
- conventions, typographic 2

D

- data collection
 - starting and stopping locally 51
 - starting and stopping remotely 57
- date
 - setting locally 22
 - setting remotely 63
- Default
 - settings, restoring locally 28
 - settings, restoring remotely 63
- DHCP
 - restarting client 25
 - using 23
- DOCSIS

- overview 67
- testing locally 68
- testing remotely 69

E

- EC Declaration of Conformity 77
- electrical specifications 78
- environmental specifications 80
- error messages, troubleshooting 74
- Ethernet - see also network
- Ethernet port
 - connecting to 7

F

- frequency counter
 - configuring 47
 - reference frequency
 - manual vs automatic 48
 - setting locally 48
 - setting remotely 61
- frequency difference
 - pausing and resuming locally 46
 - pausing and resuming remotely 60
 - scaling plot 46
- front panel 4
- fuse
 - replacing 76

H

- help, viewing for remote commands 63
- hiding markers - see markers

I

- input signal connectors 4
- installing
 - the test set 7
- integrated phase noise
 - retrieving remotely 58
 - viewing locally 38
- IP address
 - determine current 21
 - using DHCP 23
 - using static 24
- ipn - see integrated phase noise

L

- LAN port
 - connecting to 7
- linear trend - see phase difference

M

- manual reference frequency - see frequency counter
- markers
 - explained 32
 - hiding 34

- placing with mouse 33
- placing with softkeys 33
- placing with spur table 39
- measurement method 88
- model number
 - viewing locally 28
 - viewing remotely 62
- mutually exclusive options 18

N

- network
 - accessing the 5120A using 56
 - configuring 23
 - connecting to 7
- Network printer
 - printing to 28
- noise floor specifications 79
- number pad editor 17
- Numeric parameters 16

O

- Options
 - DOCSIS see "DOCSIS"

P

- panels
 - front 4
 - rear 5
- pause
 - frequency difference plot 46
 - phase difference plot 45
 - phase noise updates 38
- phase difference
 - linear trend
 - measure or remove remotely 60
 - measuring locally 43
 - removing locally 43
 - pausing and resuming locally 45
 - pausing and resuming remotely 60
 - scaling plot 42
- phase noise
 - integrated phase noise - see integrated phase noise
 - markers - see markers
 - scaling plot 30
 - snapshot 38
 - spur table - see spur table
 - test mask 35
 - zooming with mouse 31
- placing markers - see markers
- power
 - connecting 7
- powering on the test set 9
- printing
 - cancelling print jobs locally 52
 - cancelling print jobs remotely 59
 - configuring remotely 60
 - formats 26
 - printing locally 52
 - printing remotely 59
 - supported printers 26
 - to files 27
 - to network printer 28
 - to USB printer 26

R

- reference frequency - see frequency counter
- remote commands
 - viewing help for 63
 - viewing list of 63
- replacing
 - a fuse 76
- Restoring
 - factory default settings locally 28
 - factory default settings remotely 63

S

- safety instructions 7
- Scaling
 - Allan deviation plot 40
 - frequency difference 46
- scaling plots with mouse 31
- Settings Screen 21
- show mac 56
- snapshot - see phase noise
- software version
 - viewing locally 28
 - viewing remotely 62
- specifications
 - Allan Deviation 79
 - electrical 78
 - environmental 80
 - noise floor 79
 - physical 81
- spur table
 - placing marker - see markers
 - viewing locally 38
 - viewing remotely 58
- starting data collection - see data collection
- stopping data collection - see data collection
- Symbols
 - table of 1

T

- τ_0 - see Allan Deviation
- taking control - see control
- test mask
 - Allan deviation 41
 - editing 36
 - loading 37
 - phase noise 35
 - saving 37
- test set
 - calibrating 71
 - installing 7
 - measurement method 88
 - rear panel 5
 - required cables 7
 - setting up 7
 - turning on 9
- testset
 - cleaning 71
- theory of operation 83
- time
 - setting locally 22
 - setting remotely 63
- title
 - setting locally 14
 - setting remotely 62

- troubleshooting
 - error messages 74
- troubleshooting procedures 73
- turning on the test set 9
- typographic conventions 2

U

- unpacking
 - a test set 8
- USB ports
 - connection to 7
- USB printer

- printing to 26
- user specified title 14

V

- viewing
 - data remotely 66
 - help for remote commands 63
 - list of remote commands 63

Y

- yielding control - see control