TSC 5110A
Time Interval Analyzer

User Manual

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DOC05110A Rev C

Timing Solutions Corporation provides information on its products and associated hazards, but it assumes no responsibility for the after-sale operation of the equipment or safety practices of the owner or user.

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DOC05110A Rev C

Revision History

Revision	Description	Date	Approved
A	Initial Release	July 2002	DF
B	Added CE information	November 2003	DF
C	Added Declaration of Conformity. Corrected typo in Sect. IV page 26. Changed address.	2/29/04	GAR

✦✦✦ MANUAL UPDATES! ✦✦✦

There may be new information you need. Manual updates are periodically available. You can download the entire manual or specific chapters from our website at:

www.timing.com

Downloads are provided as Microsoft® WORD™ documents or as .PDF files for reading/printing via Adobe Acrobat Reader.

The last update to this manual occurred February, 2004.

TABLE OF CONTENTS

I. HOW TO USE THIS MANUAL — paper form and online

FIRST READ THIS MANUAL THOROUGHLY!
This is especially true for the sections regarding SAFETY and OPERATION.

You should read the entire manual before attempting to operate the unit. If you are reading it as a paper version, you can locate information via the table of contents and index. If you are using a computer, there are additional ways to quickly locate information:

AS ACROBAT .PDF FILE on computer

If you are reading a .PDF version on a computer using Adobe Acrobat Reader®, you may access information as follows:

- Click the "binoculars" icon at the top of the Acrobat Reader screen, or type CTRL+F, then enter a keyword in the dialogue box, and hit ENTER. You'll jump to the page containing that word and the word will be highlighted.

- Type a page number in the white slot at the bottom left of the screen, or increment pages using the left/right arrow buttons near the slot, and hit ENTER. You'll jump to that page.

AS MICROSOFT WORD DOCUMENT on computer

The manual can also be read on a computer as a MICROSOFT WORD (read only) document, assuming you've received it as a .doc file. Read it using Page Layout View. (E.g., click View on the top toolbar, then click the Page Layout button.) Following are two suggested methods to access information:

TABLE OF CONTENTS METHOD

1. Go to the table of contents. You *may* be able to do this by typing CTRL + G and entering the number 3 in the text box.

2. Place the cursor on the page number you wish to access. The cursor becomes an icon of a hand with a finger pointing. 

3. Place the finger on the appropriate page number and click. You'll jump to the intended item.

OUTLINE VIEW METHOD

1. Click the "Outline View" button at the bottom left side of your screen right next to the left arrow (◄) button. Or, on the toolbar at the top of your screen, click View > Outline.

2. In outline view, click the Number 1 button at the top of your screen to see Main Headings, the number 2 to see 2nd Level Headings, or number 3 to see 3rd Level Headings. **The third level gives more detail than you'll find in the "Table of Contents" method**.

3. Place the cursor next to the category you wish to access.

4. Click the "Page Layout" button just to the left of the "Page Layout View" button. Or, on the toolbar at the top of your screen, click View > Print Layout (or Page Layout for Word 97). You'll jump to the desired location.

"FIND" METHOD

1. Type CTRL + F.

2. Enter a keyword in the text box ("Operation", "Allan Deviation", "Instantaneous", etc.).

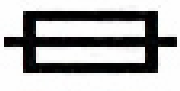
3. Click the "FIND NEXT" button or just hit ENTER, and you'll jump to the location containing that word. Repeat to go to the next location containing that keyword.

Symbols (Icons)

These symbols appear throughout the manual as well as on the unit itself.

- Warning (refer to manual) This symbol is also included with Danger, Warning and Caution boxes to identify specific levels of hazard seriousness.

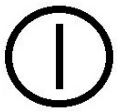
- CE marking, attesting compliance to applicable European Directives



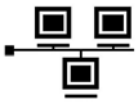
- Fuse symbol

- Input plug (Mains Supply)

- Input connector (Serial/Parallel ports)



- Power Switch, switches ON (1) and OFF (0). Mains power is ON when switch is pushed in and the green LED is lit.



- LAN port

II. SPECIFICATIONS

The TSC5110A unit is designed to meet and is tested for compliance to the following standards and directives:

DIRECTIVES

Electromagnetic Compatibility 89/336/EEC Council Directive on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive with amendments).

Safety 73/23/EEC Council directive on the harmonization of the laws of the Member States relating to electronic devices for use within certain voltage limits (LVD – Low Voltage Directive with amendments)

STANDARDS

The TSC5110A has been tested for and complies with the following Safety and EMC standards:

- EN 61010-1
- EN 61326-1, Class A.

For more information, refer to the Declaration of conformity in section VII.

ELECTRICAL

Protection Class	Class I (Grounded Type)
Power Input Voltage 	100 – 240 V~ NOTE: Fluctuations not to exceed ± 10% of nominal supply voltage.
Power Input Frequency	50 - 60 Hz
Power consumption	1.0 A (52 W maximum)
Power Inlet type	IEC 60320 sheet C14
Power Supply Cord Set	18 AWG (0.75 mm^2 minimum)
Power Mains Fuse	(2) - 250V~2A slo blo 5x20 mm

Signal Input	Impedance: 50 **Ω** / Nominal input 1 V rms (.9 - 4.5 Vpp) Frequency Range: 1.0 - 20.0 MHz

ENVIRONMENT

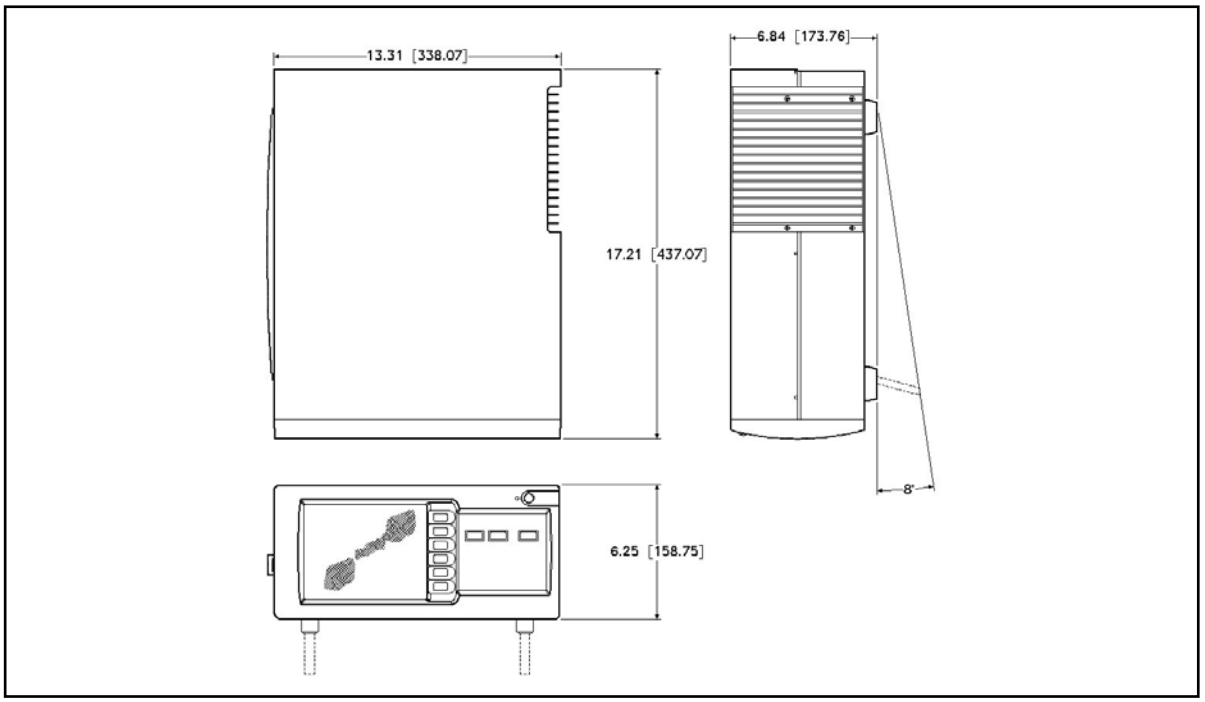
⚠ This unit is for INDOOR USE ONLY. It is not protected against a harmful ingress of moisture.

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

	Temperature	**Relative Humidity**	**Altitude**
In use	15°C to 40°C	10% to 85% (non-condensing)	3,000 meters (9,843 feet)
Storage	-25°C to 55°C	5% to 95%	
Transportation	-25°C to 70°C	95%	

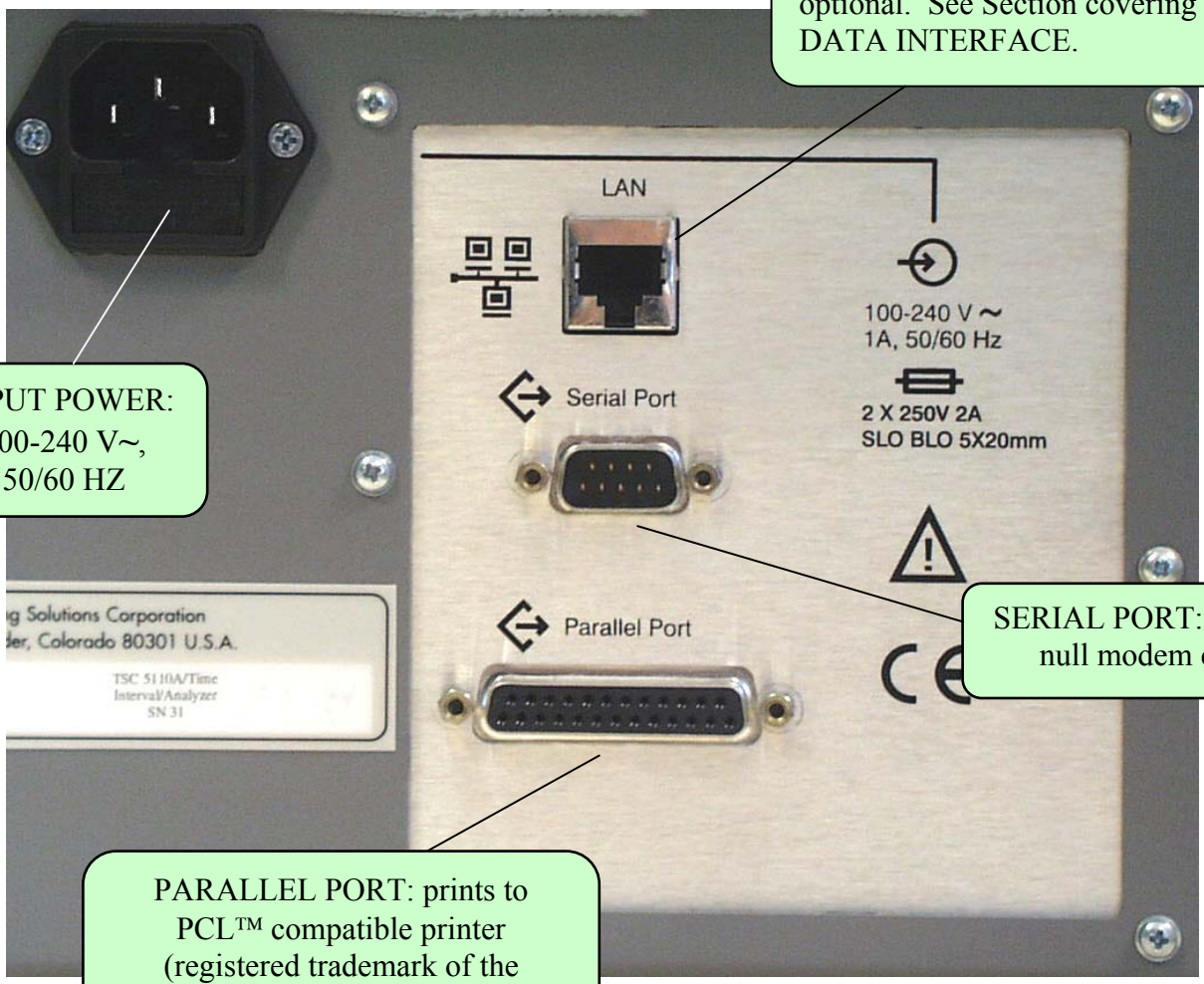
PHYSICAL

Size	33.8 cm x 17.4 cm x 43.7 cm (13.31” x 6.84” x 17.21”)
Weight	9.5 kg (21 lbs.)



LAYOUT — FRONT PANEL

LAYOUT — BACK PANEL



LAN: Ethernet Network port is optional. See Section covering DATA INTERFACE.

INPUT POWER: 100-240 V~, 50/60 HZ

SERIAL PORT: requires null modem cable

PARALLEL PORT: prints to PCL™ compatible printer (registered trademark of the Hewlett-Packard Company)

III. INSTALLATION

SAFETY FIRST!


Do not attempt to install or operate this equipment if you have not first acquired proper training.


Ensure that all cables are properly connected.


Verify that input line voltage and current capacity are within specifications before turning on the unit.


Use proper ESD precautions.


BE CAREFUL AROUND THIS EQUIPMENT!

RISK OF DEATH OR BODILY INJURY

- **Disconnect all sources of input power before trouble shooting this unit or anything connected to it.**
- **Operating and maintenance personnel must receive proper training before installing or maintaining electrical equipment.**
- **Potentially lethal voltages could cause death, serious injury, or damage to the equipment. Ensure that all appropriate safety precautions are taken.**

UNPACKING

Unpack and carefully inspect the unit. Check for physical damage. If none is apparent, then proceed with making appropriate connections. If physical damage is observed, then immediately contact Timing Solutions and the carrier. Save the shipping container for submitting any necessary claims to the carrier.

INSTALL IN A PROTECTED ENVIRONMENT, NOT SUITABLE FOR OUTDOOR USE!

CLEANING

Clean the main chassis with a soft cloth dampened with a mild soap and water solution. The LCD can be cleaned with a soft cloth dampened with a mild glass cleaner.

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

CABLES REQUIRED

- North American or European IEC power cord. One or other will be supplied with the unit.
- Two TNC male to BNC female adapters are supplied with the unit.
- Two .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.

- Note: These coaxial cables are not supplied with the unit. The unit was tested for CE compliance using 2.9 - meter cable lengths.

OPTIONAL CABLES (NOT SUPPLIED WITH THE UNIT):

- Printer cable: DB-25 connector
- RS 232 null modem cable: DB-9 connector
- Network LAN cable: RJ-45 connector

MAKING CONNECTIONS

INPUT POWER

The input power to the unit is supplied through a 3-prong power cable. First plug the female end into the input labeled **INPUT POWER** on the rear of the unit, then plug the male end into a 100V~ to 240V~, 50/60 Hz power source.

INPUT SIGNAL A and B

First connect the two signal cables to the source of the two signals, and then connect one cable to the input labeled **A** and other to the **B** input.

IT DOES NOT MATTER WHICH PORTS — A or B — ARE USED FOR THE REFERENCE AND DEVICE UNDER TEST SIGNALS.

SERIAL PORT

Connect the SERIAL PORT output with a null modem cable (not supplied with the unit) to the serial port on a PC.

PARALLEL PORT

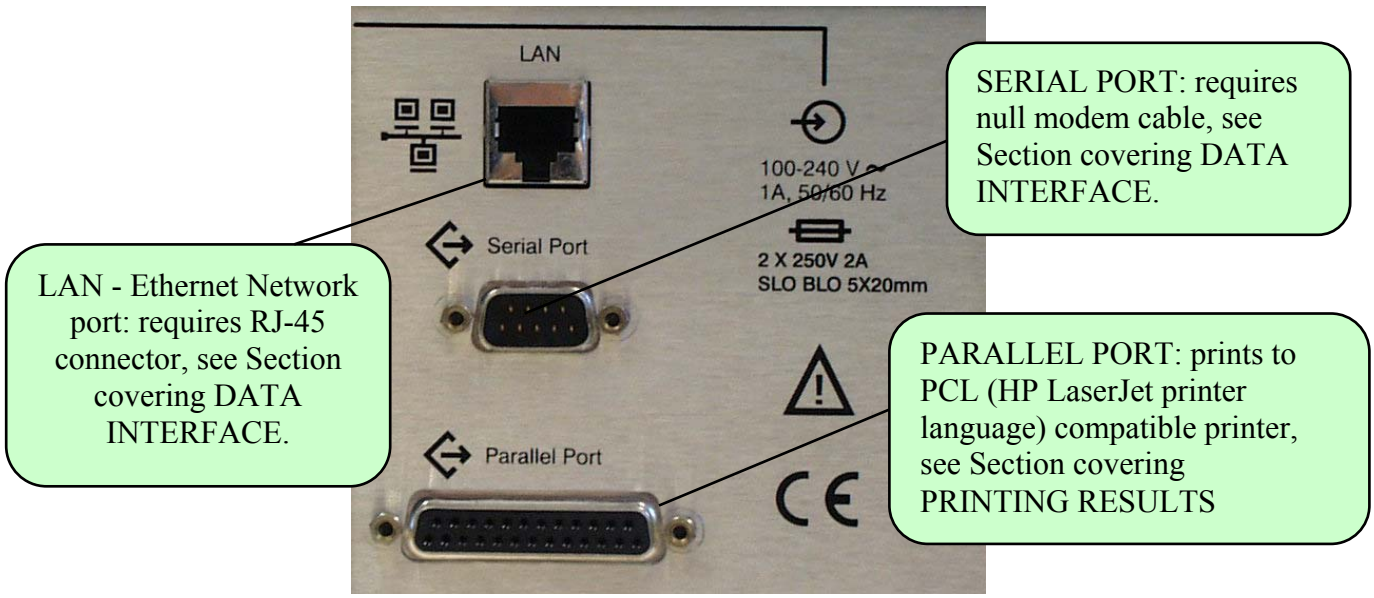
Connect a standard printer cable (not supplied with the unit) to the PARALLEL PORT on the back of the unit and to a PCL compatible printer.

Making Connections (continued)

LAN - Ethernet Network port (OPTIONAL)

Connect a network LAN cable (not supplied with the unit) to the LAN port on the back of the unit.

LAYOUT: BACK PANEL

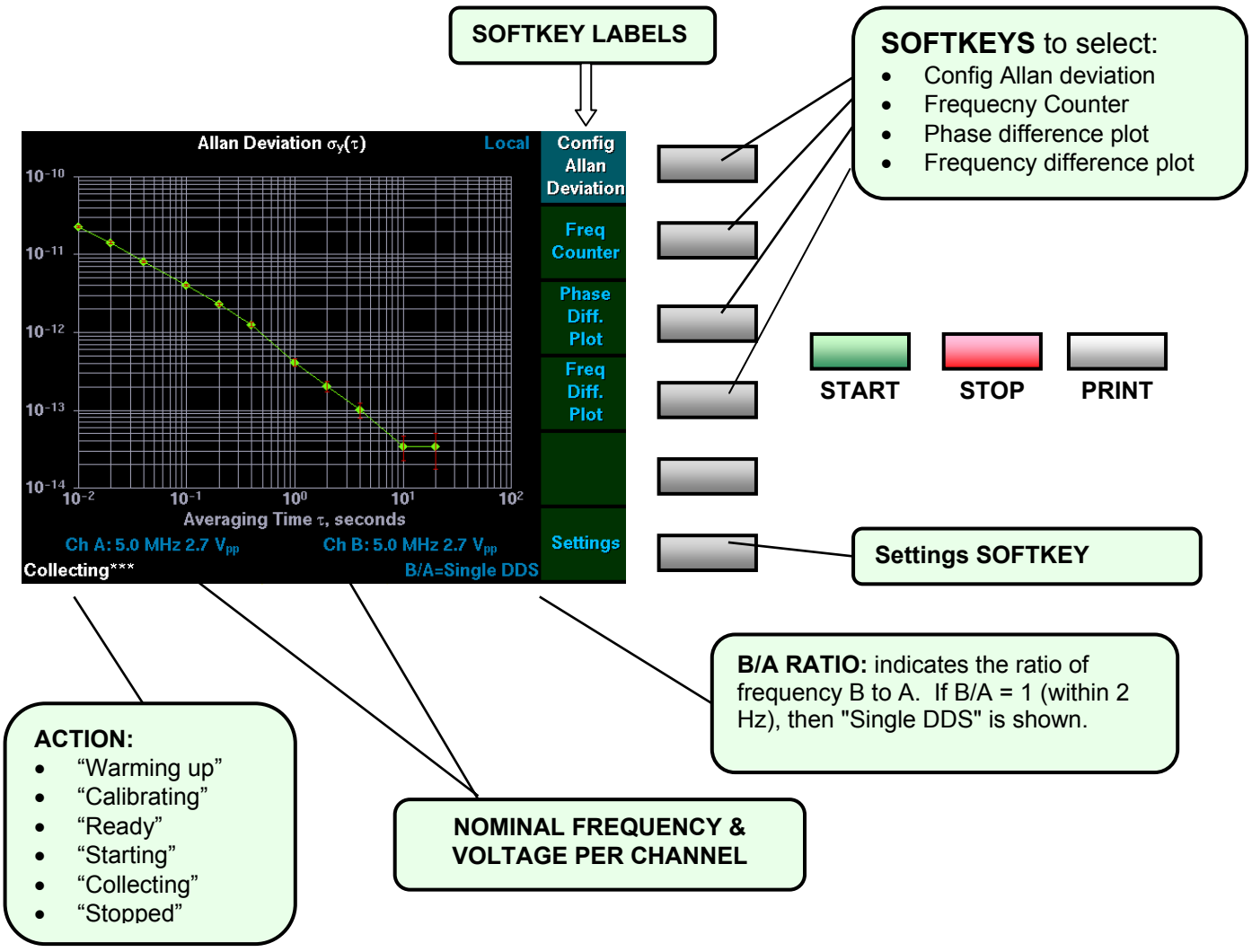


IV. OPERATION

Overview: The 5110A is designed for ease of use. There is little configuration required. Just connect two signal sources to the BNC (adapters) inputs, choose the desired algorithm option, and push start. The input impedance is 50 **Ω** and the nominal input level ideally should be near 1 V rms. The unit calibrates itself, measures the frequencies of the input signals, configures the signal paths and collects data. The user has a choice of five primary displays: the **Configure Allan deviation**, the **Frequency Counter,** the **Phase difference plot** and the **Frequency difference plot**. This instrument requires annual calibration of its internal frequency reference.

MAIN DISPLAY

(Selected Screen shows Allan deviation plot)



STARTUP

1. Press the POWER ON push button on the upper right face of the unit.

2. The display first looks similar to any PC computer screen.

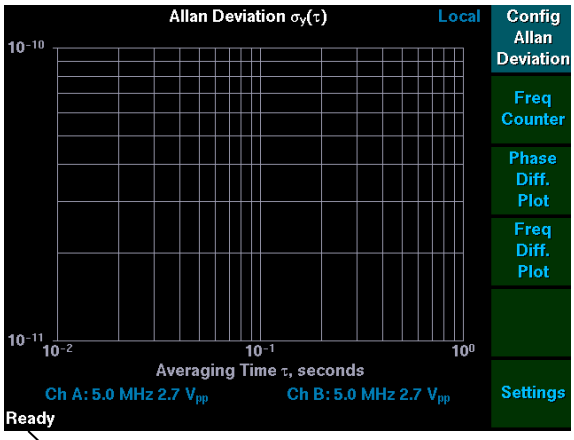
3. The Timing Solutions logo appears after 20 to 30 seconds.

4. A DIAGNOSTICS screen appears. If everything is okay with the system, it will yield to the next screen. However, if there is something wrong with the unit then a "**Self test has failed for the following item(s)…**" message will appear. Call a TSC service representative immediately.

5. The main display screen appears 40 seconds later. It defaults to the Allan deviation plot. You'll see the phrase WARMING UP in the action field on the lower left corner of the screen. (See illustration on previous page.) This lasts for approximately 1 ½ minutes.

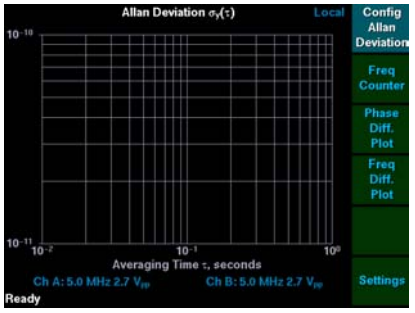
6. After a total of about 2 ½ minutes from pushing the power-on button, the unit is ready for operation, as indicated by a READY notice in the action field.

Before using the unit, you should check the configuration. See next page.



System is ready when the word READY appears in Action Field

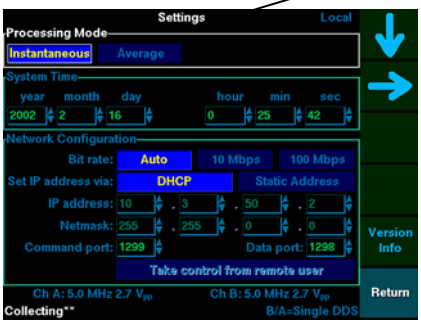
CONFIGURING



The unit initially turns on with the factory default configuration. However, you should check the appropriateness of these settings before starting data collection.

1. From a MAIN DISPLAY, push the Settings softkey.

2. The Setting screen appears.



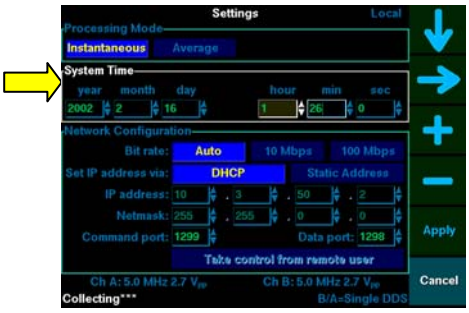
3. Push this "cycle" key to cycle through the following configuration boxes:
   - Processing Mode
   - System Time

   If the network option has been enabled, then the Network Configuration section will also be visible as shown. See Section IV, page 5.

Return to main display when finished.

CONFIGURING SYSTEM TIME

1. Push this key until SYSTEM TIME is highlighted.



2. Push this "select" key to cycle through the time windows (year, month, day, etc.).

3. Push these keys to increase or decrease the values of the active *(highlighted)* window.

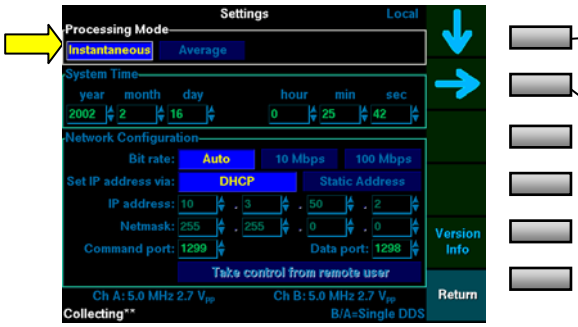
4. Push APPLY to save all changes or CANCEL to delete all changes. Review your changes or make additional changes.

5. Push RETURN to display main screen. Note: the CANCEL key will change back to RETURN when either APPLY or CANCEL is pressed.

CONFIGURE PROCESSING MODE

Check the preceding page to find out how to get to the configuration screen. You cannot make changes to the Processing Mode while collecting data! Stop data collection before attempting to change the Processing Mode by first pushing the STOP button. If you have question about either INSTANTENOUS or AVERAGE mode, then see the following page for more information. The unit is pre-configured in the INSTANTENOUS mode.

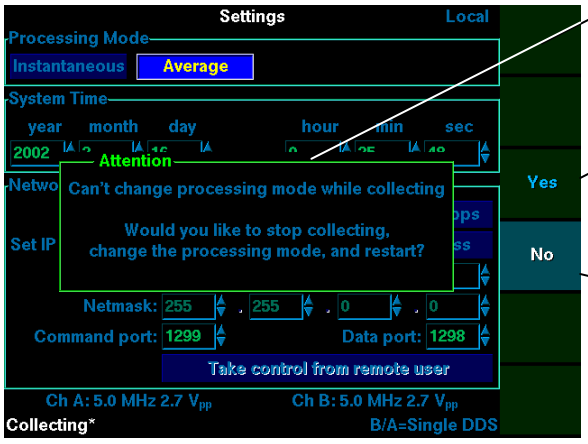
1. Stop collecting data by pushing the STOP button on the keypad.



2. Push this key until the Processing Mode box is highlighted.

3. Push this key to select Instantaneous or Average. See next page for further discussions of these terms.

NOTE: You cannot make configuration changes to the Processing Mode while collecting data! If attempted then the following message will appear.



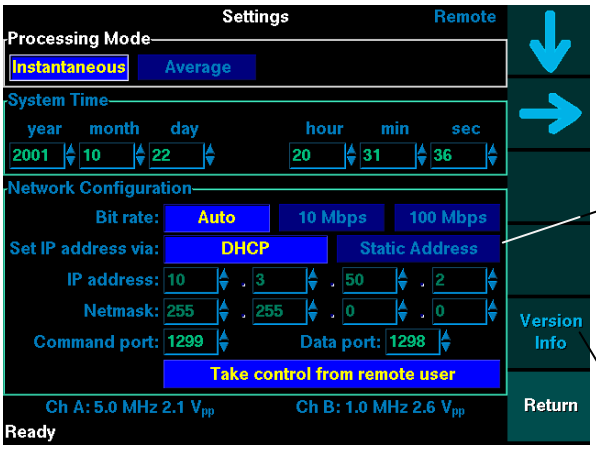
Press this key if you want to stop collecting data in order to change the Processing Mode.

Select this key to return to prior Processing Mode.

CONFIGURING ETHERNET NETWORK (LAN)

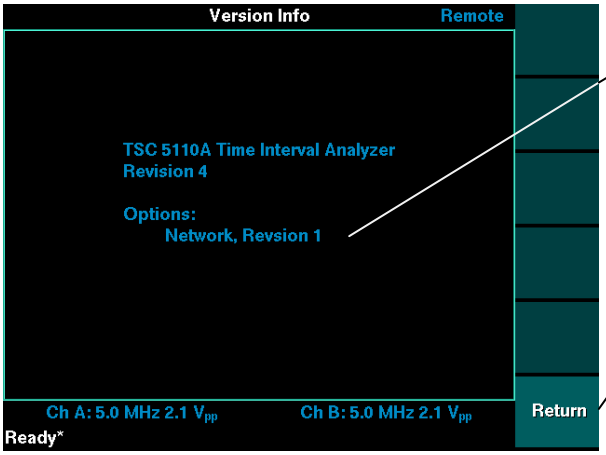
The network option can be specified when ordering the TSC 5110A or your unit can be upgraded later to add this capability. If your unit has the RJ-45 connector for the network (LAN) port on the back panel of the unit and you are not sure if the network has been enabled, then check the information displayed on the SETTINGS and VERSION INFO screens. The SETTING screen provides a means to configure the network.

To configure the network, first check if the network is enabled:
1. Access the SETTINGS screen.



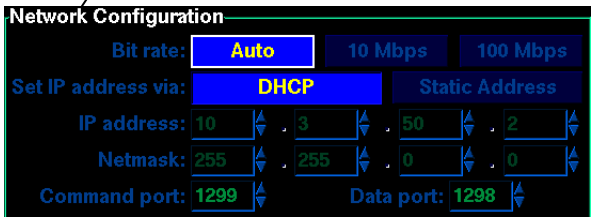
2. Network is enabled, if the Network Configuration section is visible as shown here. If not, then contact Timing Solutions Corporation to purchase a software upgrade.

3. You can also check the Revision number of the Network software by selecting VERSION INFO.



4. Press RETURN to return to the SETTINGS screen to complete the network configuration.

5. Move to the Network Configuration section on the SETTING screen using DOWN arrow until the heading is highlighted.



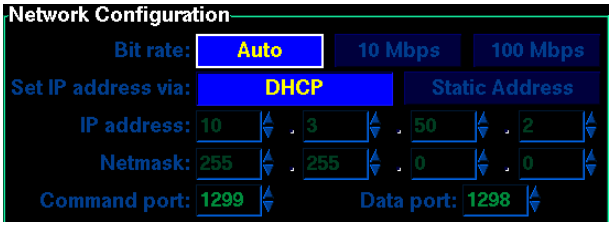
Configuring the Network:

Default Values for the network	
Bit Rate:	**Auto**
Set IP address via:	**DHCP**
IP address:	**(none)**
Netmask:	**(none)**
Command port:	**1299**
Data port:	**1298**

The default values for the network can be used if you have a DHCP server. However, the IP address and netmask will not be determined until the unit is physically connected to the LAN, because the unit will attempt to negotiate an IP address with your DHCP server. **You must know the IP address, the Command port and the Data port before you can communication with your unit via the network.**

Bit Rate: (Auto, 10 Mbps or 100 Mbps)

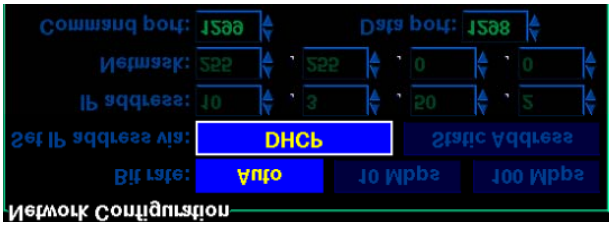
Bit Rate can be AUTO, 10 Mbps or 100 Mbps. AUTO allows the server to negotiate the appropriate bit rate. Alternatively, the bit rate can be fixed by selecting either 10 Mbps or 100 Mbps.



Use the RIGHT arrow to move among the BIT RATE options. Then press APPLY if finished or continue to the next field with the DOWN arrow.

Set IP address via: (DHCP or Static Address)

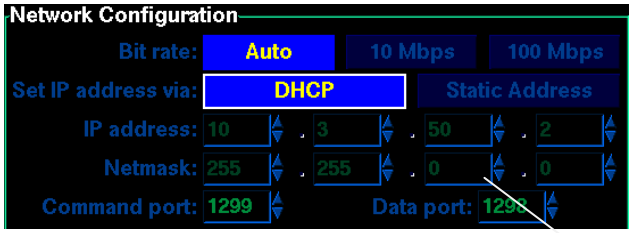
The IP address and netmask can be manually set (Static Address) or automatically set by your DCHP server can automatically set it. In either case, the IP address must be known before you can connect to unit.



Use the RIGHT arrow to move between the two options. Then press APPLY if finished or continue to the next field with the DOWN Arrow.

DHCP

DHCP mode requires that you have a DCHP server, check with your network administrator if you are unsure. Your DHCP server will assign a unique IP address and netmask to your unit. Also, the DHCP must be able to receive broadcast traffic from the TSC 5110A.



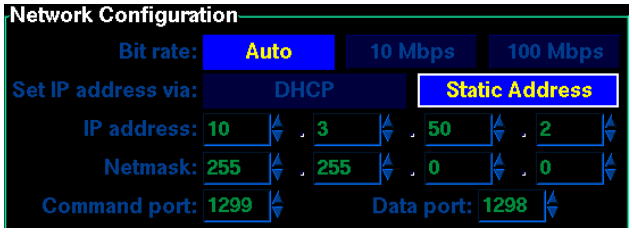
If you are selecting DCHP for the first time, then the IP address and netmask will not be assigned until the unit is physically connected to the LAN.

Your unit will attempt to negotiate an IP address and netmask with your DCHP server. Afterwards both will be displayed on the SETTINGS screen.

Note: When using DHCP, the value of the IP address is up to your DHCP server. In addition, your server may occasionally decide to tell the unit to change its IP address. If and how often this might occur depends on the configuration of your DHCP server. Contact your network administrator for more information.

STATIC ADDRESS

Static Address mode allows you to manually set the IP address and Netmask. Each is made up of four oclets(separated by periods) : e.g. IP address is 10.3.50.2 as shown below. Each of the four oclets can range from 0 to 255.



Select Static Address using the RIGHT arrow, then press the DOWN arrow to move to the IP address field.

Manually entering the IP Address

Note: You must determine a unique IP address for this unit before entering it here.

Enter each of the four segments of the IP by using the "+" and "-" softkeys. The IP address must be unique to this unit.

Each segment of the IP address must be set using the "+" and "-" softkeys. A "repeat key" features allows you to quickly change the number if either softkey is held for a few seconds. Use the RIGHT arrow to move among the four segments. Press APPLY when finished, or the DOWN arrow to move to the next field.

Manually Entering the Netmask

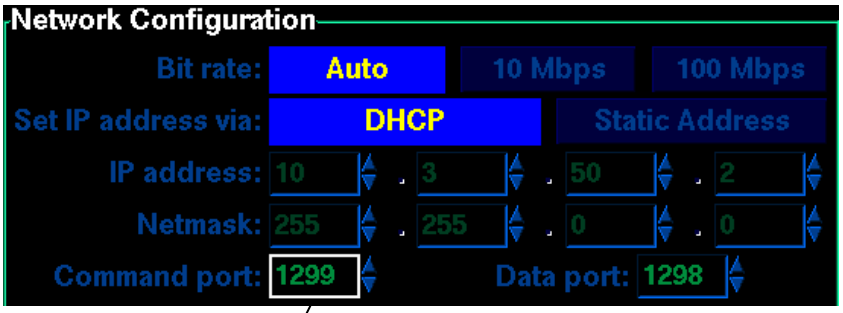
Enter each of the four segments of the IP by using the "+" and "-" softkeys. The IP address must be unique to this unit.

Each segment of the IP address must be set using the "+" and "-" softkeys. A "repeat key" features allows you to quickly change the number if either softkey is held for a few seconds. Use the RIGHT arrow to move among the four segments. Press APPLY when finished, or the DOWN arrow to move to the next field.

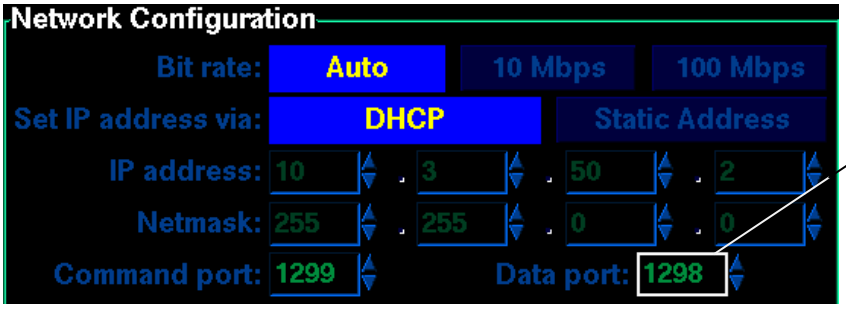
Command and Data ports

Note: You must determine unique Command and DATA port values before entering them here.

You can use the default values for the COMMAND (1299) and DATA (1298) ports, or you change either one to a unique value. The values can range from the lowest unreserved port number to the largest allowable port number. In either case, you must know these values before you can communicate with the unit via the network.



Change the value for the Command port by using the "+" and "-" softkeys. A "repeat key" feature allows you to quickly change the number if either softkey is held for a few seconds. Press APPLY when finished or the Right arrow to move to the DATA port field.



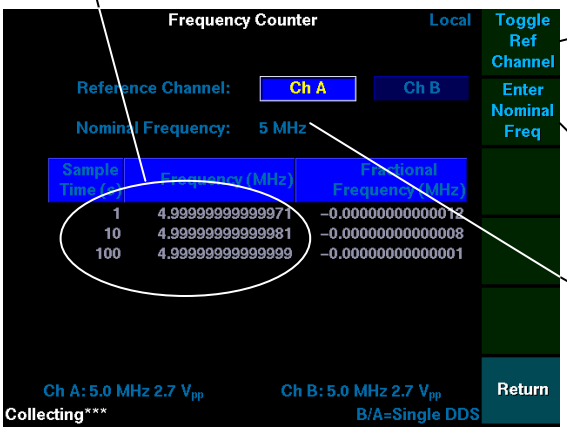
Repeat process for the DATA port, press APPLY when finished.

CONFIGURING FREQUENCY COUNTER

The Frequency Counter can be configured either before or after data collection begins. The configuration procedure will be identical either way. The Frequency Counter can compute either A referenced to B, or B referenced to A. In addition to selecting which input is designated the reference frequency, the precise value of the reference frequency or Nominal Frequency can set using a numeric keypad. When equal frequency inputs (Single DDS mode) are being measured, then Fractional Frequency will also be displayed.

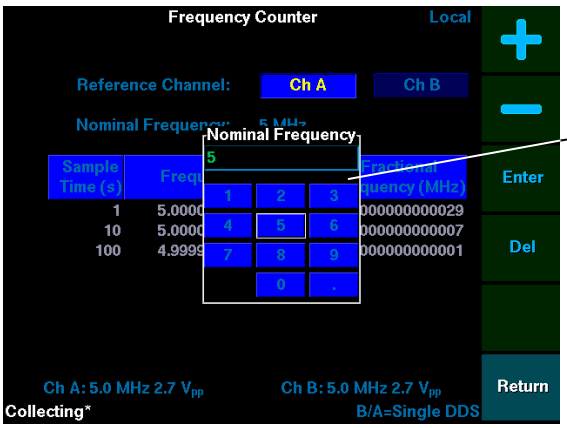
To configure the Frequency Counter, press the Freq Counter softkey from the main display screen, then the Config Freq Counter softkey

If data has been collection for at least 100 seconds, then all three frequency averages (1, 10 and 100 seconds) will show on the screen.



Press Toggle Ref Channel to switch between A and B as the reference channel. Note: this can be done while collecting data.

To change the Nominal Frequency default value (5 MHz shown here), press the Enter Nominal Freq softkey. The default value is determined by the nominal frequency of Channel A.



Use the keypad to change the Nominal Frequency value by pressing either the "+" or "-" softkey to highlight the desired digit (including the decimal point). Then press Enter or Del to add or remove the highlighted digit. When finished, press Apply.

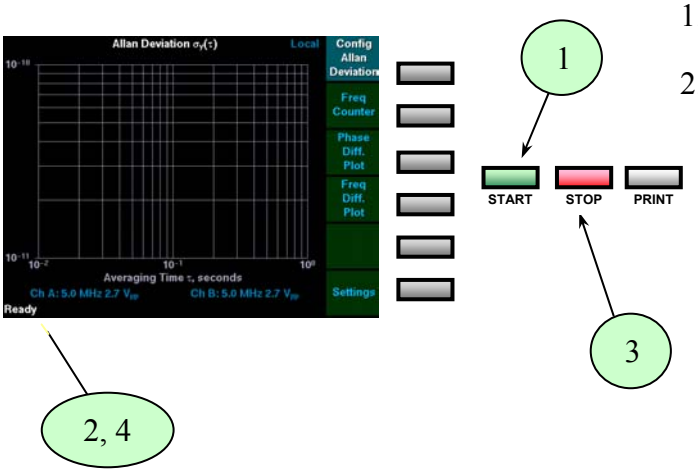
COLLECTING & VIEWING DATA

The oscillator you are testing is the DUT (Device Under Test). Be sure it is plugged into port A or B, and the reference oscillator plugged into the remaining port.

BEFORE STARTING, decide between INSTANTANEOUS and AVERAGE methods to determine Allan deviation data.

- The Instantaneous method computes the mean frequency over interval (τ) from the difference between the ending and starting phases and conforms to the IEEE standard for computing the Allan deviation.
- The Average method averages several phase measurements within each sampling interval to compute the mean phase and computes the frequency over the interval (τ) from the difference between the ending and starting mean phase. The resulting frequency deviation is similar to the modified Allan deviation.
- The noise floor of the instrument is typically 10 dB lower using the Average method.

To select the Instantaneous or Average method, follow the procedure described under "CONFIGURE PROCESSING MODE" on the previous page. When you are ready:



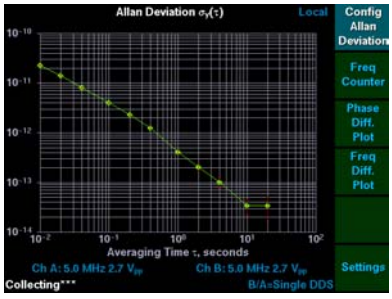
1. Push the START button.
2. The action field will indicate Starting for three seconds while the unit decides to operate in single or dual DDS mode (See *Theory* Section). Then you'll see a 33-second countdown while the unit is Calibrating. Finally, the field will indicate Collecting as data appears on the display.

   Results for sampling interval (τ) will appear after 4τ seconds. For example, forty seconds will elapse before data is displayed for a sampling interval of ten seconds
3. Push the STOP button when finished collecting data or when you want to configure unit.
4. The action field will indicate Stopped after you have pushed the STOP button. Then Ready* will appear after a few seconds indicating that the unit is ready data collection.

VERY IMPORTANT!

DO NOT BUMP, VIBRATE, OR OTHERWISE DISTURB THE INSTRUMENT OR THE SIGNAL CABLES DURING OPERATION.

DO NOT ALTER THE FREQUENCY (MORE THAN 1 Hz) OF EITHER INPUT WHEN THE UNIT IS COLLECTING DATA.

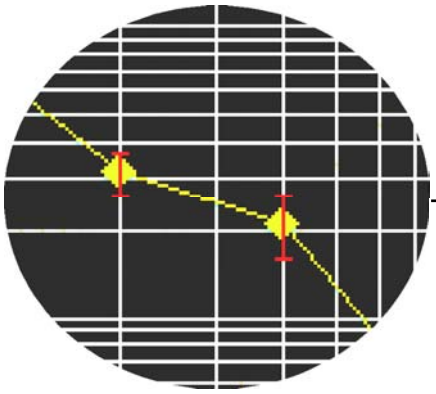


Push the appropriate softkey at any time to access:

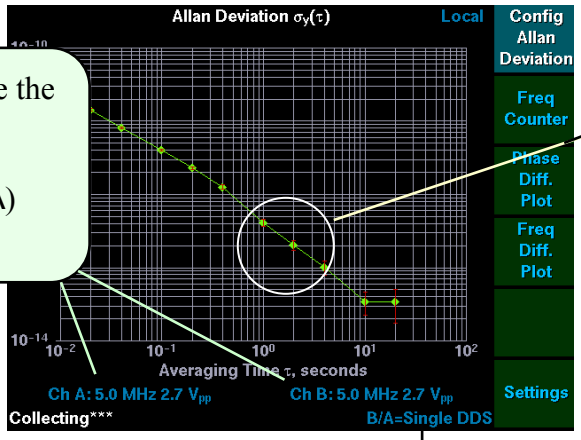
- Config Allan Deviation
- Frequency Counter
- Phase difference plot
- Frequency difference plot

- In the event data collection has been stopped, (by pushing the STOP button), screens display data just collected.
- The just-collected data will be retained until a new run is started or until the unit is turned off.
- Data may be collected for 400,000,000 seconds, about 12.5 years. The largest sampling interval (τ) is 400,000 seconds.
- Print any screen before beginning the next data collection period by pushing the PRINT button with the desired screen displayed on the LCD.
- Tables and plots can be printed either during data collection or while in the stopped state.
- The unit automatically turns off its LCD back-light if left idle or collecting for more than 4 hours, just press any softkey to view the last displayed screen.

STATUS INFORMATION



Allan Deviation Plot: **Red** vertical lines indicate confidence interval. They diminish as data are collected. (See *Theory* Section



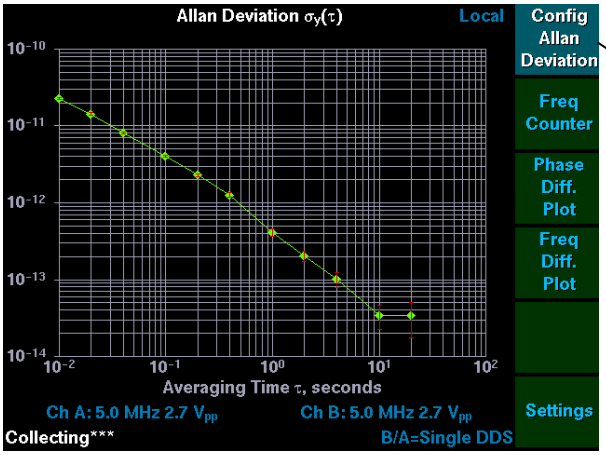
These status fields indicate the frequency in MHz and amplitude in peak-to-peak volts for Channel A (Ch A) and Channel B (Ch B).

Other notifications may appear in Action Field. See *Troubleshooting* section for details.

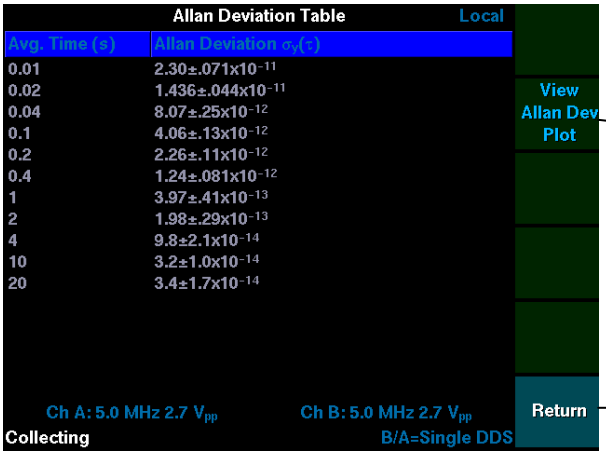
This field indicates the ratio (B/A) that represents the nominal ratio of the frequency of the signal applied to Channel B to the frequency of the signal applied to Channel A. However when B/A = 1 (within 2 Hz), then "Single DDS" will be displayed.

ALLAN DEVIATION PLOT and TABLE

The Allan Deviation Plot is the default display after the system is ready. You can access the Allan Deviation Table as well as by pushing Config Allan Deviation softkey and selecting the View Allan Dev Table option.



To view the Allan Deviation Table, press the Config Allan Deviation softkey. Then push the View Allan Dev Table softkey.

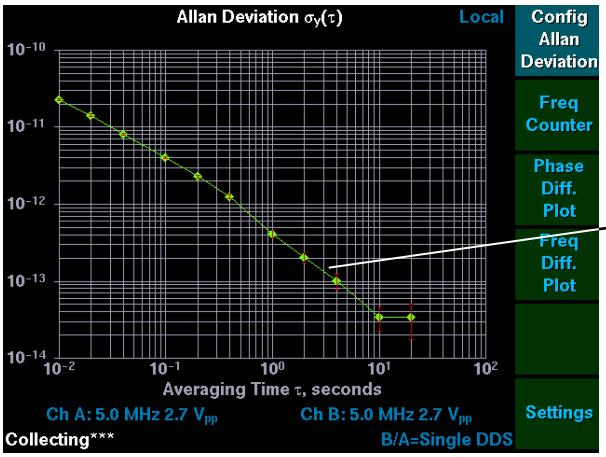


To return to the Allan Deviation Plot, just press the View Allan Dev Plot softkey.

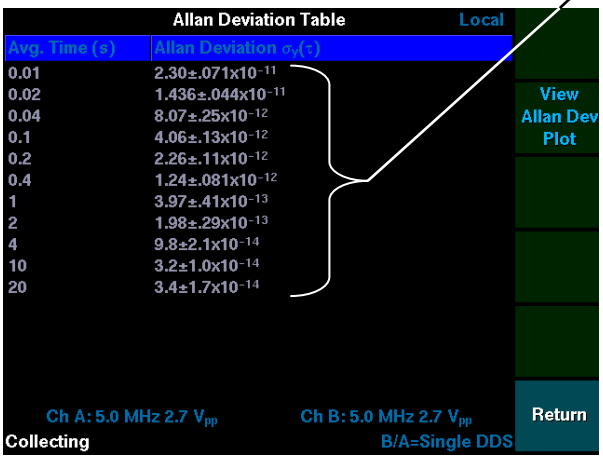
Press Return to display the main display screen.

The screen last selected (either the Plot or the Table) will continue to appear after the Return softkey is pressed.

The Allan deviation Table, like the Allan deviation Plot, continuously updates when the unit is collecting data. The Allan Deviation value for each averaging time displayed includes a ± confidence interval. The confidence intervals are displayed as vertical red lines on the plot. You'll find more details in the *Theory* Section (Section V).



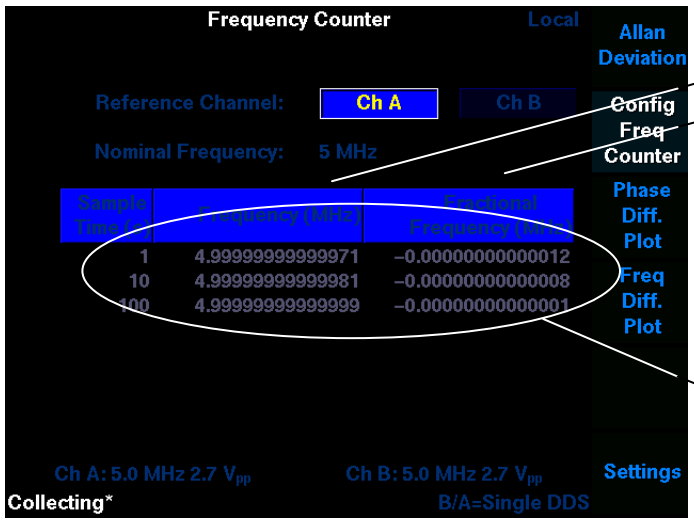
Red vertical lines indicate confidence interval and correspond to the ± confidence values shown on the table. They diminish as data are collected.



Note: When the table fills the display screen then UP and Down arrows will appear, press these softkeys to scroll up or down the rows of data.

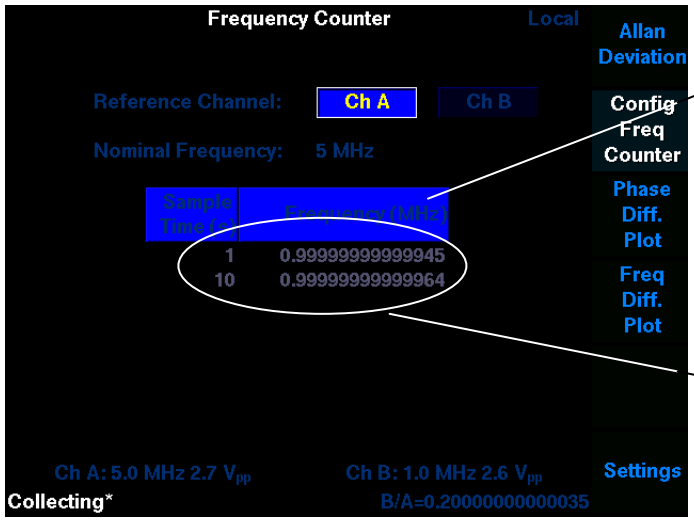
FREQUENCY COUNTER SCREEN

The Frequency Counter continually computes and displays three frequency averages (1, 10 and 100 second) by comparing one input to the other. In Single DDS mode (equal frequency inputs), the screen also displays Fractional Frequency. Note that the Nominal Frequency value will be displayed as "0 MHz" during "Calibrating" until "Collecting" begins, then the frequency value of Channel A (or Channel B if selected) will be displayed.



The Frequency Counter screen displays both average frequency and fractional frequency when both inputs are equal frequency (Single DDS mode).

The 1, 10 and 100 second data are shown here.



Only the average frequency is computed when the two inputs are different frequencies (Dual DDS mode).

Only the 1 and 10 second averages appear here, because the current data collection period is less than 100 seconds.

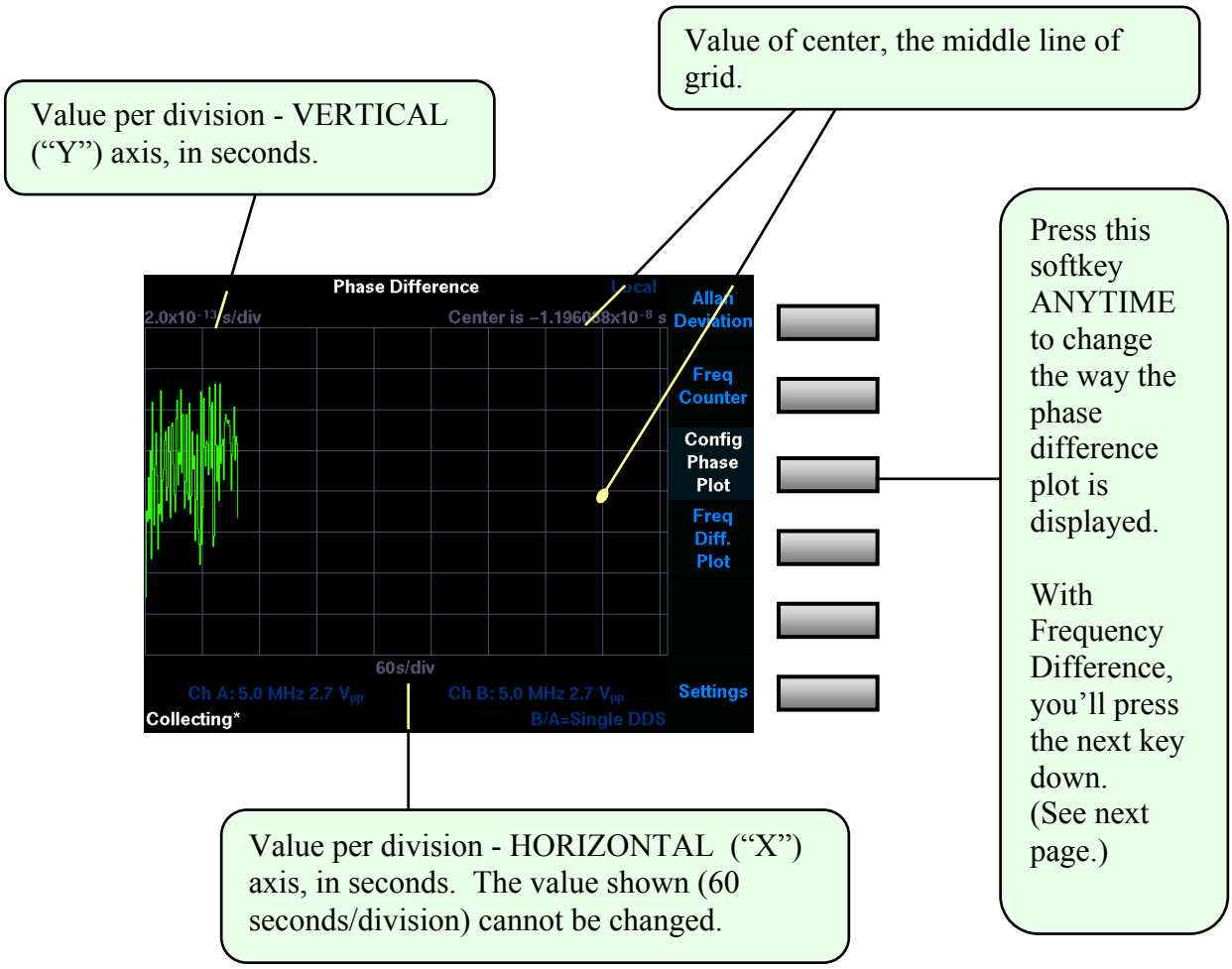
NOTE: ALL FREQUENCY DATA DISPLAYED ON THE SCREEN WILL DISAPPEAR WHEN THE "STOP" BUTTON IS PRESSED.

PHASE and FREQUENCY DIFFERENCE PLOTS

You can access the Phase Difference and Frequency Difference plots from main display screen.

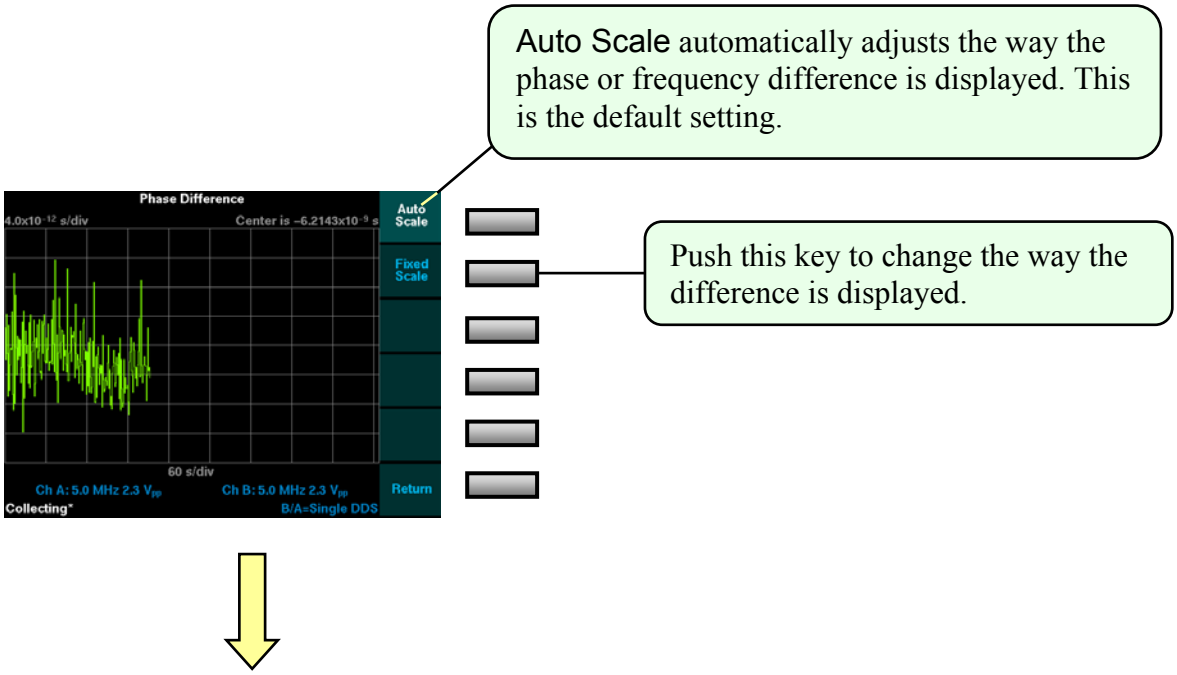
The phase difference and frequency difference plots are real-time displays of the values measured each second.

The plot continues to update as long as the unit is collecting data. After approximately 9 minutes, the display pans to the right so that new data are visible.

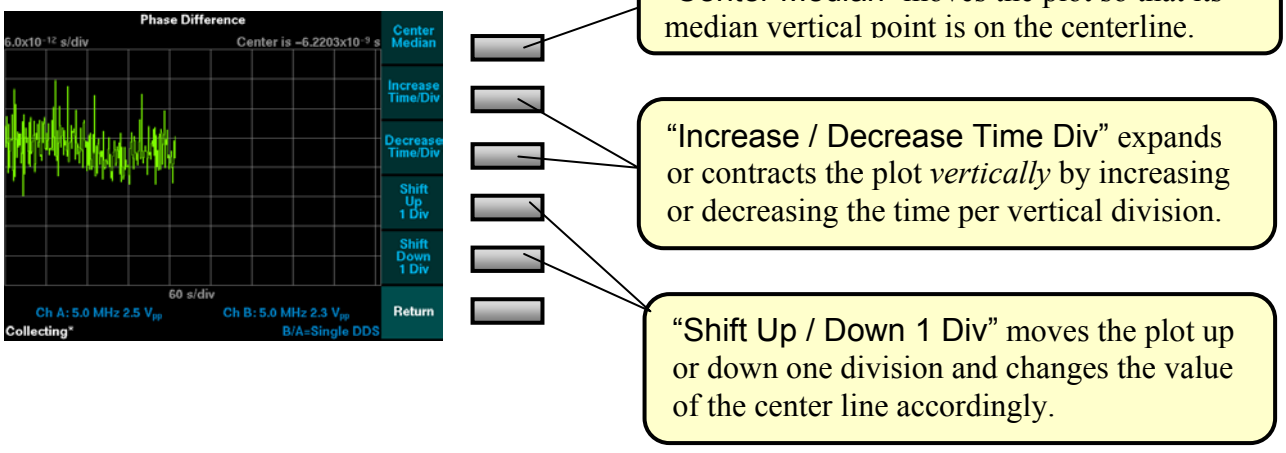


CONFIGURE PHASE / FREQUENCY DIFFERENCE DISPLAYS

You can change the way that you view the phase or frequency difference displays data. The Phase Difference is shown in the example. Frequency Difference works the same way.



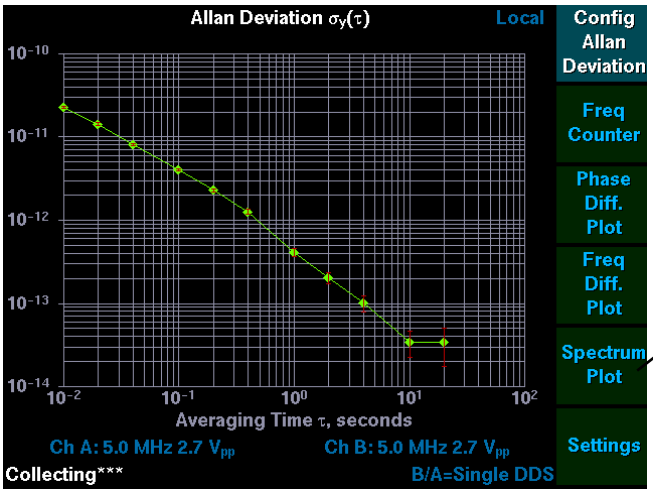
After you've pushed the Fixed Scale key…



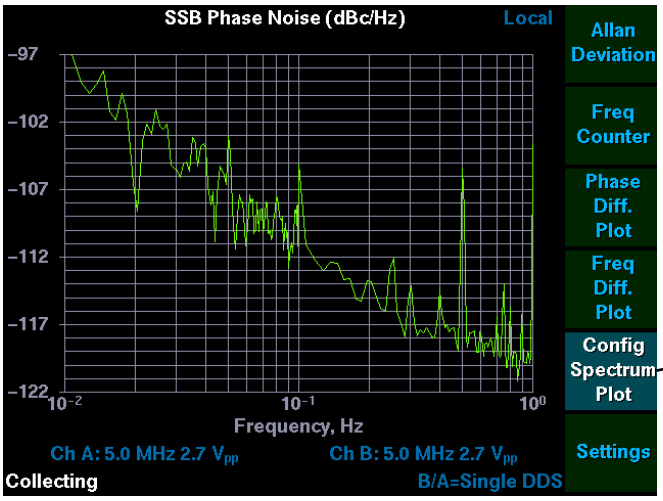
SSB PHASE NOISE PLOT (OPTIONAL)

The SSB Phase Noise function automatically displays the inside 1.0 Hz (close to the carrier) information on one screen accessible using the Spectrum Plot soft-key pad on the front of the unit. Information first appears on the log-log screen approximately 100 seconds after "Collecting" begins, then the screen updates every 100 seconds thereafter. The first decade of the information to be displayed is the 10^{-1} - 10^{0} Hz range. The longer the data collection period, the more data is available to display the "close-to-the-carrier" information.

SSB Phase Noise Plot is enabled, if the Spectrum Plot softkey is visible on the main screen. If not, then contact Timing Solutions Corporation to purchase a software upgrade.



To view the SSB Phase Noise Plot, select the "Spectrum Plot" softkey on the main screen. If this softkey is not shown, then the SSB plot is not enabled.

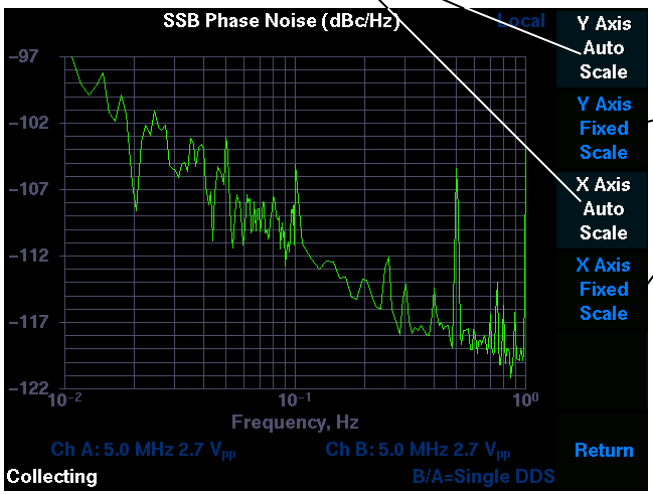


Select "Config Spectrum Plot" to change the scaling of either axes (see the following page).

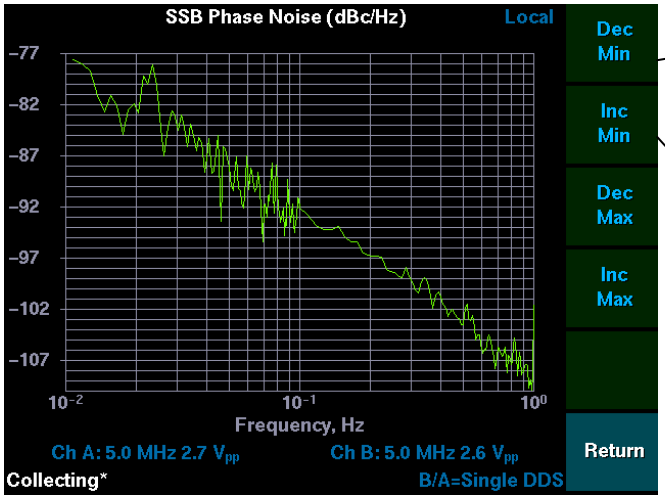
CONFIGURING SSB PHASE NOISE PLOT

The SSB phase noise plot only displays "close in" data (inside 1 Hz from the carrier). This plot does not need to be configured prior to initiate data collection. However the screen can be expanded or compressed to assist with viewing the data. In addition, you can adjust either the horizontal or vertical axis at any given time, not both simultaneously. You can move the horizontal axis to the right, however no data will be displayed outside 1 Hz.

"X-Axis Auto Scale" and "Y-Axis Auto Scale" automatically scales the horizontal and vertical axes respectively to the maximum full scale.



"X-Axis Fixed Scale" and "Y-Axis Fixed Scale" allows you to adjust either the horizontal and vertical axes and takes you to the screen below.

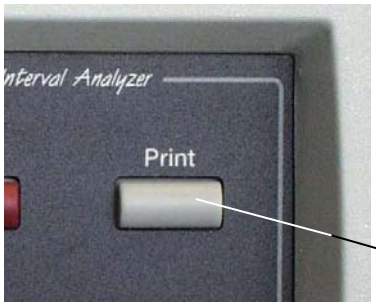


"Dec Min" holds the far right or the top of the screen and decreases the scale on the far left or the bottom depending on which axes you selected.

"Inc Min" also holds the far right or the top of the screen and increases the scale on the far left or the bottom.

Likewise, the "Dec Max" and "Inc Max" holds the far left or the bottom of the screen and increases or decreases the far right or the top of the screen

PRINTING RESULTS



Any of the plots or the table can be printed using the Print button on the front of the unit. The 5110A prints to any printer that can interpret PCL (HP LaserJet printer language). PCL is a registered trademark of the Hewlett-Packard Company.

IMPORTANT!

Printing is not queued. Only the current displayed screen will be printed when PRINT is pressed. Printing must be completed before another screen can be printed.

You must also complete printing before START button is pressed, since current data is lost when you start the next round of data collection.

DATA INTERFACE - SERIAL PORT

Format	**ASCII**
Baud	**9600**
Bits	**8**
Parity	**none**
Stop bit	**1**
Flow control	**none**

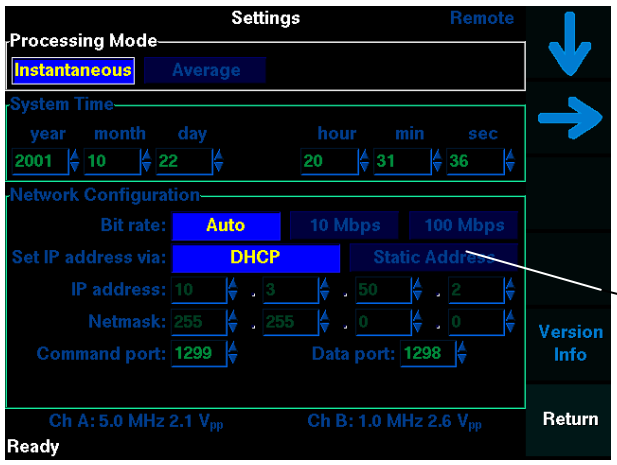
The 5110A supports an RS-232 data interface on the rear of the unit. The data connector is a DB-9 male and is configured the same as a computer RS-232 port. Therefore, in order to make a connection with a PC to download data, one must use a crossover cable (null modem cable) that connects pin 2 at one end to pin 3 at the other and vice versa. Pin 5 should be connected to pin 5. The port is configured for 9600 baud, no parity, 8 bits, and 1 stop bit. There is no flow control.

The output data are the 1-second phase-difference measurements. **The units are cycles of the frequency of Channel A.** Instantaneous phase measurements are output when the instrument is in "instantaneous" mode. One-second block averages of the time differences are output in "average" mode. The measured phase difference data are a string of ASCII decimal ('.') and numeric ('0'-'9') characters representing a floating point number followed by an ASCII carriage return (0x0D) and an ASCII line feed (0x0A) - one line per record. The measurements may be captured in a terminal emulator (e.g., use the 'Capture Text' features of HyperTerminal available in Windows™) and analyzed in Excel™ spreadsheet or optional Stable32 software.

DATA INTERFACE - NETWORK PORT (OPTIONAL)

The network option is a controllable (start/stop/print) Ethernet IEEE 802.3 port. The network provides a means to download real-time phase difference data and remotely control the unit from a PC connection. When the collecting data in Single DDS mode, 10 ms phase difference data will be output. Otherwise, 100 ms data will be output. **The units are cycles of the frequency of Channel A.** Up to five connections can be made to the data port to receive phase difference data. In addition, one connection can be made to the Command port. This provides a means to remotely start, stop or print a screen (via the printer port only). When the unit is being remotely controlled via the Command port, then local control will not be permitted. However, a local operator can change to the displayed screen (see section VI, pages 8 & 9) or initiate printing a screen (see section VI, page 11) from the front panel.

The network option can be specified when ordering the TSC 5110A or your unit can be upgraded later to add this capability. If your unit has the network hardware (LAN) port on the back panel of the unit and you are not sure if the network has been enabled, then the information displayed on the SETTING and VERSION INFO screens will indicate so. The SETTING screen provides a means to completely configure the network.



Before attempting to make a network connection, first check if the network is enabled by accessing the SETTINGS screen.

Network is enabled, if the Network Configuration section is visible as shown here. If not, then contact Timing Solutions Corporation to purchase a software upgrade.

Default Values for the network

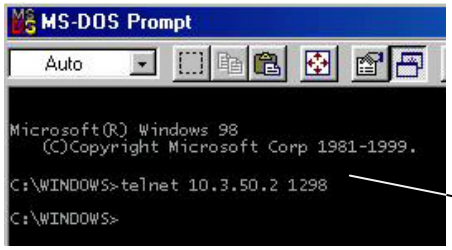
Bit Rate:	**Auto**
Set IP address via:	**DHCP**
IP address:	**(none)**
Netmask:	**(none)**
Command port:	**1299**
Data port:	**1298**

The network comes pre-figured from the factory, however refer to Section IV pages 5 - 9 for detailed information on configuring the network. The default values for the network can be used as is if you have a DHCP server. However, the IP address will not be determined until the unit is physically connected to the LAN, because the unit will attempt to negotiate an IP address and Netmask with your DHCP server.

Connecting to the Data port using Telnet:

Connecting to the Data port on your unit allows you to view and collect phase difference data on your PC via a network connection. **The units are cycles of the frequency of Channel A.** A maximum of (5) connections can be made to the data port. Telnet is a common utility that can be used to connect to the Command port, the following shows the Windows™ version.

Note: you must know the IP address and the Data port value. These can be viewed by accessing the SETTINGS screen from the main menu as shown on the previous page. The unit must be powered "ON".

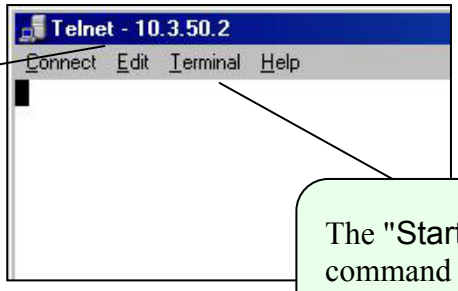


1. Select the DOS prompt on your PC.
2. Enter "telnet [IP Address] [Data Port]" as shown.

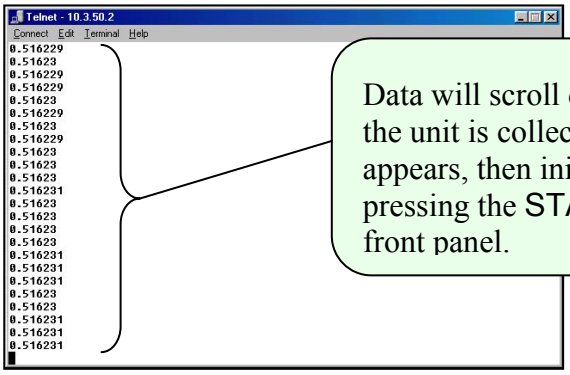
The IP address shown in this example is 10.3.50.2. The Data port is 1298 (default).

3. This will open a telnet window.

If you have successfully connected, then you can view the IP address here. If "(None)" appears, then check the IP address and Data port values and try again.



The "Start Logging…" command under Terminal to store data in a file.



Data will scroll down the page when the unit is collecting data. If no data appears, then initiate a start by pressing the START button on the front panel.

4. Disconnect by closing the telnet window.

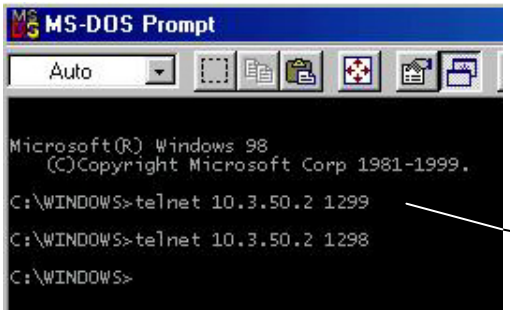
Connecting to the Command port using Telnet:

Connecting to the Command port on your unit allows you to control your unit from a PC using Start, Stop and Print commands. When you open a Command port connection, a local operator can use the softkeys and issue a Print command. In addition, a local operator can return the unit to local control by overriding the Command port connection. Telnet is a common utility, the following shows the Windows™ version.

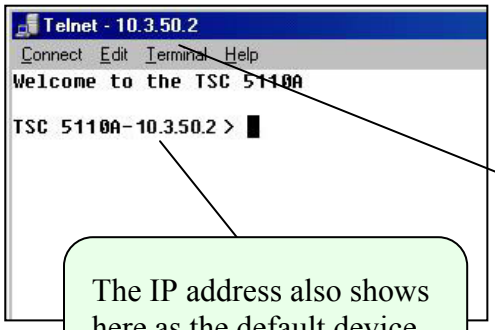
Note: you must know the IP address, the Data port and the Command port values. These can be viewed by accessing the SETTINGS screen from the main menu as shown on page 17. The unit must be powered "ON".

You will also need to open a Data port connection in order to view data from the your PC.

1. Enter "telnet□[IP Address]□[Data Port]" as shown.
2. Enter "telnet□[IP Address]□[Command Port] as shown.



The IP address shown here is 10.3.50.2. The Command port is 1299 (default) and the Data port is 1298 (default).



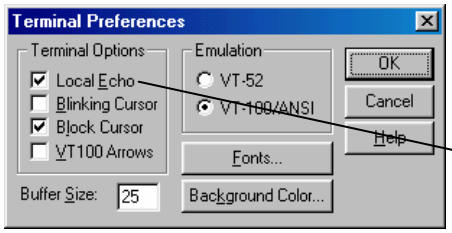
If you have successfully connected, then you can view the IP address here. If "(None)" appears, then check the IP address and Control port values and try again.

The IP address also shows here as the default device name.

3. This will open (2) telnet windows, one for the Command port and other for the Data port. Only the "Command" window is shown here.

Command port continued:

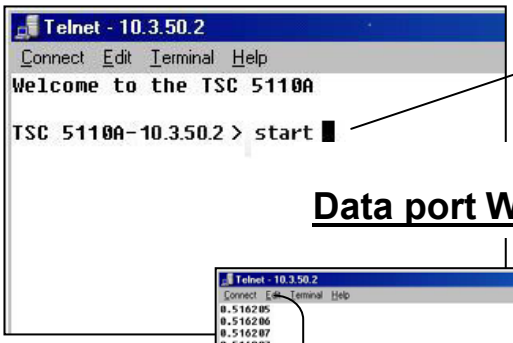
4. Before continuing, select the "Local Echo" option under Terminal.



Select "Local Echo" under Terminal to view your typed input on the screen.

5. To start data collection, type "set□control□remote" and ENTER. Then, type "start" and Enter. Data will start scrolling on the Data port window approximately 33 seconds later.

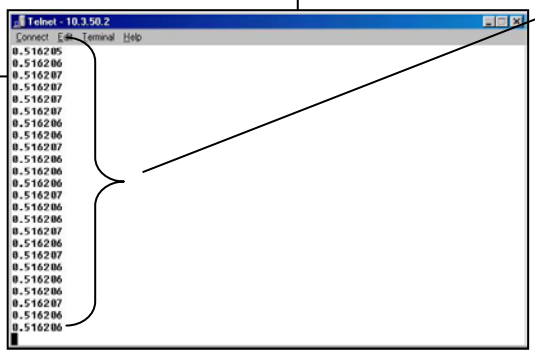
Command port Window



Type "set□control□remote" and ENTER, then "start" and ENTER.

About 33 seconds later, data will start scrolling in the Data port window.

Data port Window



Note: If data does not appear after 1 minute, then check for an error message on the front panel display of your unit. Consult the TROUBLSHOOTING section for more details concerning any error message.

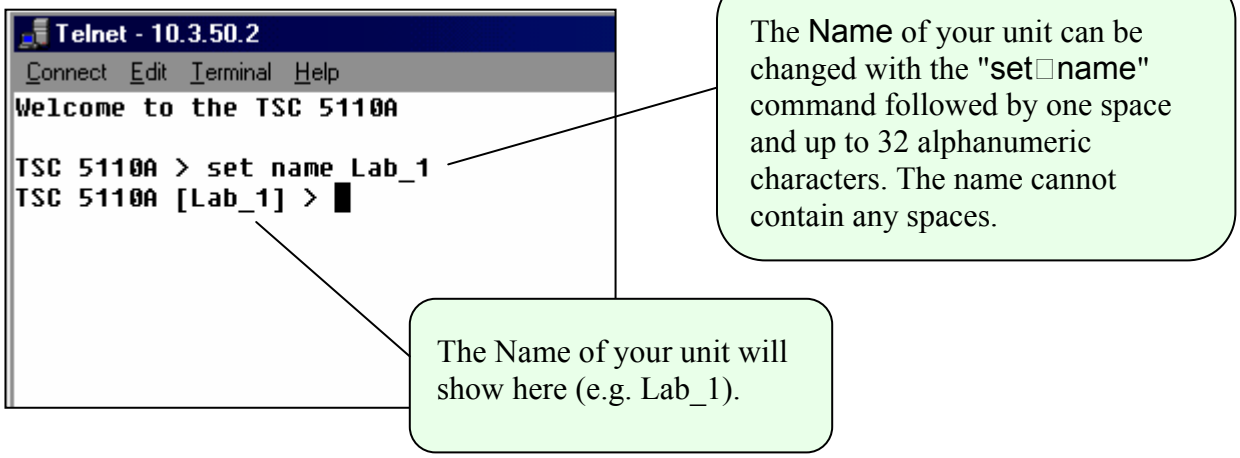
6. To stop data collection, type "stop" and ENTER in the Command port window.

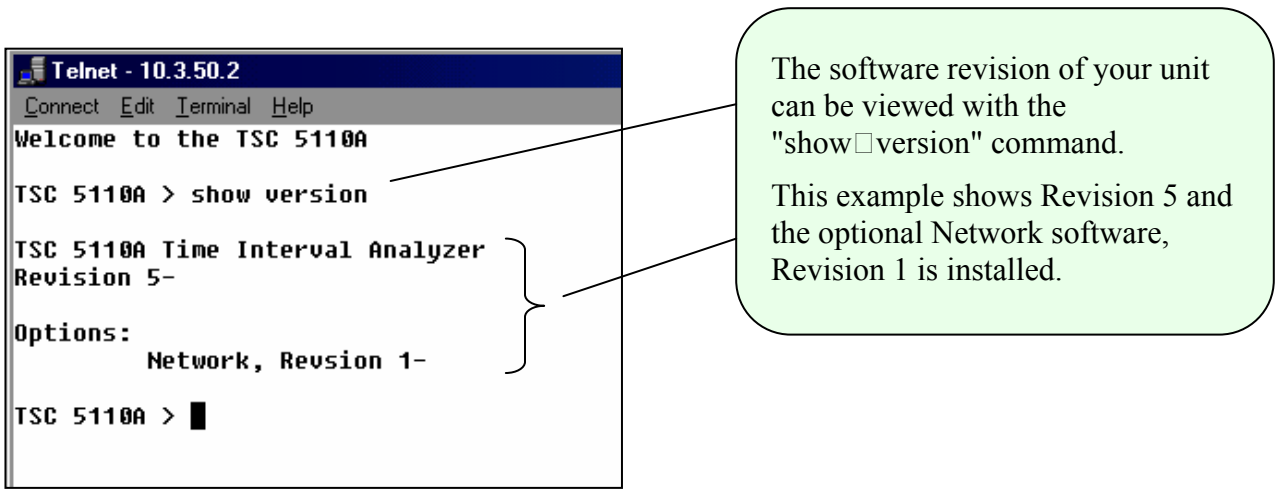
7. To return to local control, type "set□control□local" and ENTER.

8. To disconnect, close either or both windows.

Command port continued:

Additional commands allow the user to specify the Name of the unit using the "set name" command, "set control" changes the control mode (local, remote or none), and show version displays the unit currently software revision information.



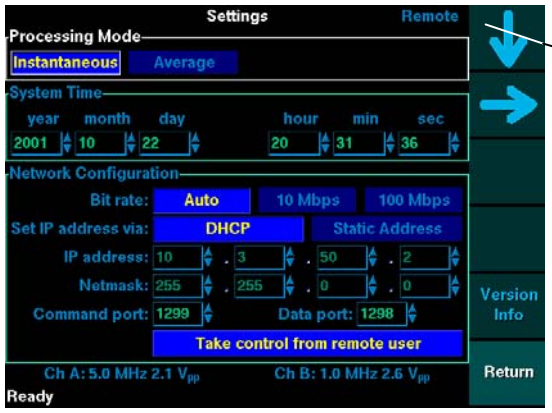


List of all commands:

start	Starts data collection
stop	Stops data collection
set control	(remote, local, none)
show version	Displays current software versions and options
set name	Set the displayed name of the unit

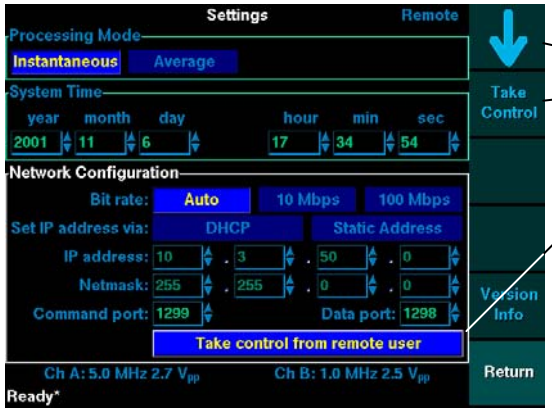
Overriding the Command port from the Front Panel Display:

A local operator can override the Command port (or remote control) from the front panel display and return the unit to local control. Any screen will indicate if the Command port is currently open and in control.



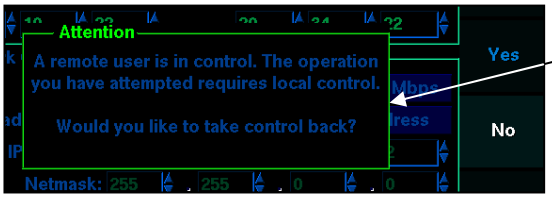
When a remote user has control of the unit, "Remote" will be visible in upper right-hand corner of all screens.

A local operator can return the unit to local control by accessing the SETTINGS screen and selecting "Take Control" softkey when the "Take control from remote user" box is highlighted.



To take control from a remote user, use the "Down" arrow to highlight the "Take control from remote user" box and push the "Take Control" softkey.

An alternate means of returning to local control is also available from the front panel.



If an operator presses either the "Start" or "Stop" button when unit is in remote control, then an Attention box will appear with the option to take back control. Pressing the "Yes" softkey will immediately return the unit to local

Connecting the Unit Directly to a LAN port on a PC:

You can directly connect from the network (LAN) port on a PC to your unit using a "cross-over" cable instead of the standard network cable. Refer to Section IV, page 8 to set the IP address and netmask on your unit. All commands will be same regardless of the method (direct connection or via a LAN) that you choose to connect the unit.

Set the identical netmask on both your PC and your unit.

Example: **Netmask:** **255.255.0.0**

Set the IP addresses to unique values.

Example: **IP address (PC):** **10.10.10.1**

IP address (TSC 5110A): **10.10.10.2**

Note: Your PC should be able to auto-negotiate the Bit Rate. If you incur a problem, you may have to set the Bit Rate to either 10 or 100 Mbs by selecting it on the Settings screen.

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V. THEORY

The ALLAN DEVIATION

The Allan deviation is named after its originator, David Allan. It describes mathematically the measurement-to-measurement deviation in a sequential series of frequency measurements. Compute the Allan variance from the equation:

$$\sigma_y^2(\tau) \approx \frac{1}{2(N-1)} \sum_{j=1}^{N-1} (y_{j+1} - y_j)^2$$

where y_j is the j^{th} frequency measurement and N is the total number of frequency measurements.

Find the square root of the Allan variance. This will be the Allan deviation.

Typically, about 68% of the frequency deviations will be within the range indicated by the Allan deviation; about 95% will be within the range of two times the Allan deviation, and about 99% will be within the range of three times the Allan deviation.

SAMPLING INTERVALS

The instrument makes phase measurements using the heterodyne method using a nominal Intermediate Frequency (IF) of approximately 100 Hz when equal frequency oscillators are compared. The smallest sampling interval, or tau (τ), is one period of the IF or 10ms. After four intervals are sampled for a period of 40ms, data are displayed at the 10 msec point.

As data are collected, increasing sampling intervals are displayed. The progression of sampling intervals, in terms of seconds, is: .01, .02, .04, .1, .2, .4, 1, 2, 4, 10, 20, 40 …etc.

In "Averaging" mode, the mean of the phase measurements within each interval are averaged and each average is used to calculate the frequency. In "Instantaneous" mode, the

last phase measurement in each interval is used to compute the frequency. "Instantaneous" mode corresponds to the true Allan deviation as defined by the IEEE. "Averaging" mode reduces the measurement noise, but is a non-standard statistic. Remember that data in four intervals are collected before the Allan deviation is displayed for each τ value. For example, forty seconds will elapse before data are displayed for a τ of ten seconds.

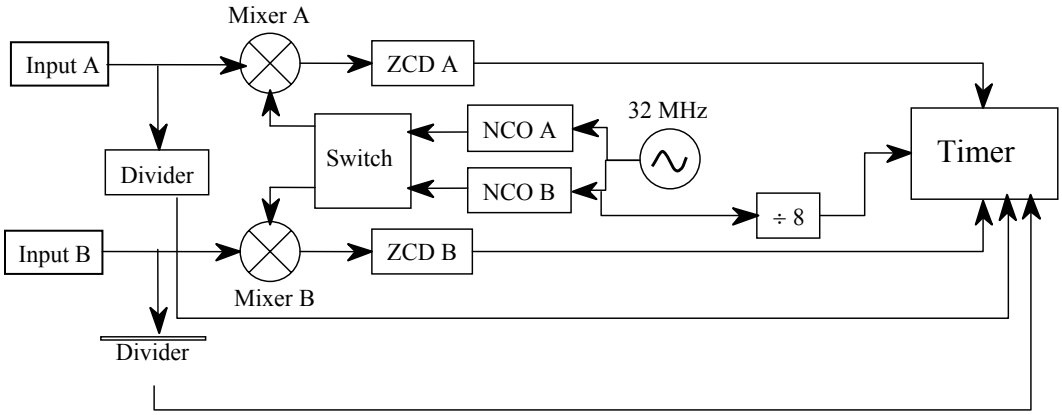
CONFIDENCE INTERVAL

See the *Operation* Section (Section IV) covering Allan Deviation Plot and Table for how the confidence interval is displayed. It is computed as $0.99/\sqrt{N}$, which is valid for white phase noise and flicker phase noise and slightly optimistic for more divergent noise types.[1].

The table will fill in for increasing averaging times and continue for each averaging time until 1,000 points have been used to compute the average. After 1,000 points have been collected, the average is complete for that averaging time. When enough data has been collected to fill the screen, additional points are viewed by scrolling down the screen using the softkeys on the right of the screen. The unit will continue to update Allan deviation values until 400,000,000 seconds (12.5 years) of data has been collected.

ANALYZING METHOD

The following is a simplified block diagram of the TSC 5110A Time Interval Analyzer signal flow.



The two input signals (A & B) are mixed with offset reference signals to produce separate low frequency beat signals. Zero-crossing detectors (ZCD) enhance the slew rate of the beat signal and then the timer time tags the zero crossings and counts them.

Two dividers, which feed divided replicas of the input signal to the timer, provide the information needed for automatic operation, but do not contribute to the high precision phase difference measurements. The divided signals are used to make coarse measurements of the frequencies of the two inputs. Each of the two Numerically Controlled Oscillators (NCO) is then set to beat with its respective input to achieve an IF of approximately 100 Hz. A high precision measurement of the frequency of each input results from the determination of the period of the IF.

Divider

Timer

Divider

One of two modes of operation, which we call **Single DDS Mode** and **Dual DDS Mode**, is selected based on the frequency difference between the two inputs.

Single DDS Mode

The instrument enters Single DDS Mode when the two inputs are within 2 Hz of one another. One of the NCO's is bypassed and the switch connects the output of the remaining NCO to both mixers. The instrument operates as a standard Dual Mixer Time Difference Measurement System. The nominal frequencies of the inputs appear on the screen of the TSC 5110A and all high precision outputs should be interpreted as the time of B relative to the time of A in units of input A. For example, the "phase plot" shows the time of the signal on channel B less the time of the signal on channel A in units of seconds as determined by the nominal frequency of channel A. The slope of the plot represents the offset frequency between the two inputs. The slope is positive when the residual frequency of B minus A is positive. At 5 MHz, the maximum slope is 2 Hz or 4×10^{-7} s/s, whereas at 1 MHz, the maximum slope of 2 Hz corresponds to 2×10^{-6} s/s.

[1] P. Lesage and C. Audoin, Radio Science, Vol. 14, No. 4, pp 521-539, 1979.

In Single DDS Mode the noise of the 32-MHz internal oscillator and the NCO cancel out for data collection periods greater than 10 ms. As a result, the instrument contributes the least possible noise to the measurements.

DUAL DDS Mode

The instrument enters Dual DDS Mode when the two inputs differ in frequency by 2 Hz or more. The switch connects the output of each NCO to its respective mixer. The nominal frequency of each input appears on the screen of the TSC 5110A and all outputs can still be interpreted as B relative to A in units of input A. For example, suppose that a 5-MHz reference has been connected to input A and a 2.048-MHz Device Under Test (DUT), which actually has a frequency of 2.04800000572 MHz, has been connected to input B. The screen shows the results of three measurements. First, the nominal frequency of A in the form Ch A: 5.0 MHz. Next, the nominal frequency of B in the form Ch B: 2.0 MHz. Finally, the ratio of the two frequencies in the form B/A=0.4096000012. This nominal ratio has been used to remove the frequency difference between the two inputs in order to plot the residual phase or frequency differences. All of the outputs should be interpreted as B relative to A in units of input A after the removal of the nominal frequency difference. The “phase plot” shows the residual time difference after removing the nominal accumulated time difference. Once again, it is the time of the signal on channel B less the time of the signal on channel A in units of seconds as determined by the nominal frequency of channel A. The slope of the plot represents the residual offset frequency between the two inputs. The slope is positive when the frequency of B is greater than that of A. In general, the slope will be quite small since it represents a combination of the inaccuracy of the initial 33 s frequency calibration and any changes in frequency that happen after that time.

A more accurate frequency difference between ports B and A can be determined from the elapsed phase displayed on the “phase plot” or “frequency plot.” For example, the fractional frequency displayed on the “frequency plot” can be added to the displayed ratio to obtain the true ratio of the nominal frequency of the B input relative to the A input.

The error represented by one-half the least significant digit of the displayed ratio is a fractional frequency of 1×10^{-13}.

Time Difference Measurements

All calculations within the TSC 5110A are performed using the measured phase difference between the signals applied to the two inputs. The phase of the input is sampled at a nominal rate of approximately 100 samples per second, but the rate may be as low as 10 samples per second. The sampling is performed by a "zero crossing detector (ZCD)" followed by an event timer that records the time of the zero crossings of the IF signal produced by the mixer. By definition, the phase increases 2π each time a positive going zero crossing has occurred. The data from each input are re-sampled to common, equally spaced, coincident time points and subtracted to obtain the final time series of the phase difference between channels A and B. When equal frequency oscillators are compared, the sample rate is 100 samples per second and the Allan variance is computed starting at a sample time of 10 ms. When unequal frequency oscillators are compared, the sampling rate is lower and the minimum sample interval for the computation of the Allan variance increases.

VI. TROUBLE SHOOTING

Perform all of the following procedures before returning the unit for service. If the unit still appears to have a problem, then call Timing Solutions Corporation and request technical support. Have the serial number of your unit ready to give to a technical representative. Note: This instrument requires annual calibration of its internal frequency reference.

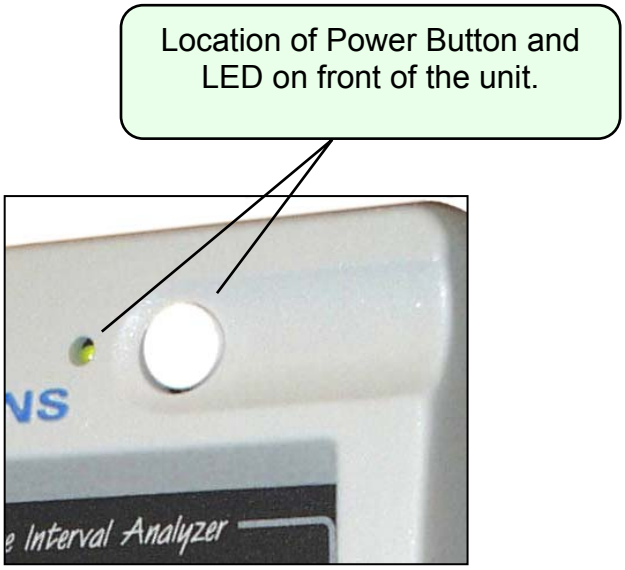
Danger!
Do not remove the top cover for any reason! The only serviceable parts are the fuses accessible from the back panel. See the following page for details.

Checks with the Power turned off

Warning!
RISK OF DEATH OR BODILY HARM.
Disconnect all sources of input power before working on this unit or anything connected to it.

1. Ensure your power source is turned off.
2. Check for visible damage in the unit, cables, plugs and connectors.
3. Ensure that all plugs and connectors are correctly installed and fastened.
4. Check to determine if any input power circuit breakers have been tripped.
5. Ensure that your power source is within specification.

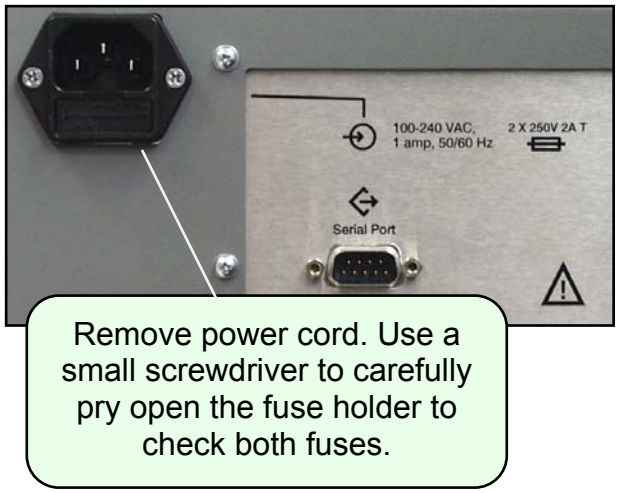
Check with the power on



6. Push in the power button on the front of the unit. Check that the green LED on the unit near the power switch is lit. If it does not come on and your power source has been thoroughly checked then unplug the unit from its power source and check both fuses mounted in the power entry module located on the rear of the chassis. (SEE BELOW) Replace if necessary with 250V 2A slo blo 5x20 mm fuses. Check your power source if fuses need replacing before re-plugging in the power cord.

WARNING!
Do not attempt to check fuses with power cord plugged into the unit.

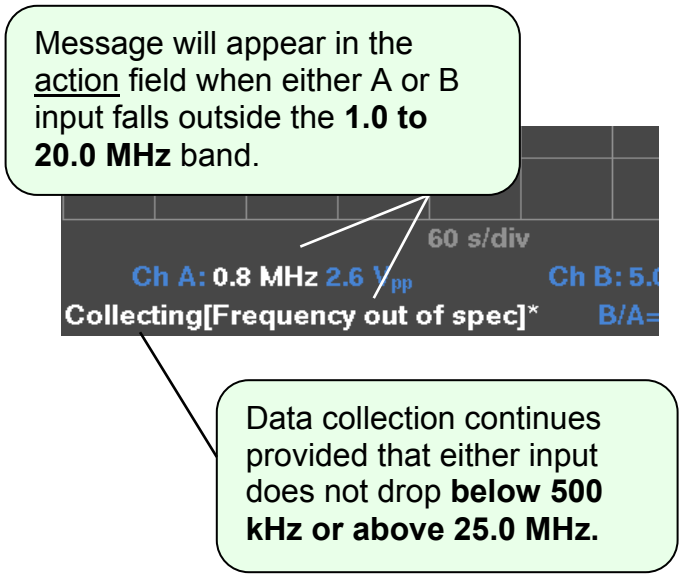
Fuse Location



7. Observe the Logo Screen.
8. If a "**Self test has failed for the following item(s)…**" message is displayed during start-up, then contact a TSC service representative.
9. Press the STOP button, and then press START.
10. Observe the "Calibrating" message along with the countdown timer in the lower left-hand portion of the LCD. The unit should begin collecting data after 33 seconds.
11. See the *OPERATION* section for more details on the Start up procedure.

Trouble shooting Messages

- **DATA COLLECTION CONTINUES EVEN THOUGH EITHER A OR B INPUT FALLS OUTSIDE THE *SPECIFIED LIMITS*.**



Both A and B inputs must be between within **1.0 MHz to 20.0 MHz**. If one or the other falls above or below this limit, then the following message will appear in the action field.

[Frequency out of spec]

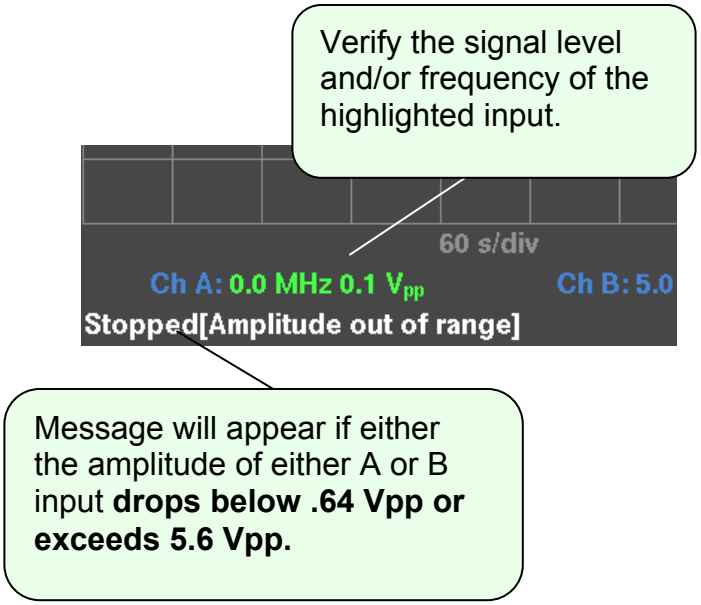
A similar message will appear if the amplitude of either input falls outside a **.9 Vpp - 4.5Vpp** limit.

[Amplitude out of spec]

These messages will latch and reset only when unit is stopped.

NOTE: the frequency of either input should not be altered more than 1 Hz during data collection.

- **HOWEVER, DATA COLLECTION WILL NOT BE ALLOWED IF EITHER A OR B INPUT EXCEEDS THE *MAXIMUM OPERATNG LIMITS*.**

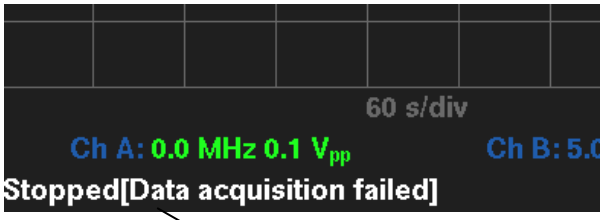


Data collection will not continue if the amplitude drops **below .64 Vpp or exceeds 5.6 Vpp.**

Check the signal level and/or frequency of the highlighted input, then push the START button to continue.

More Trouble shooting Messages

- **Both inputs on Channel A and B must be stable during the 33-second calibration period that occurs after the START button is pressed.**



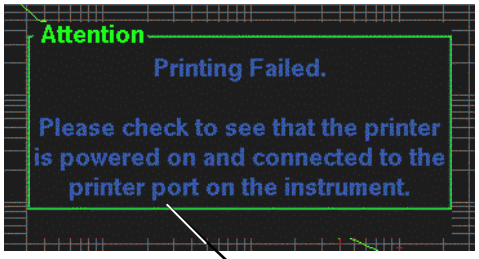
If this message appears, then check both inputs before re-cycling the power button.

This message can occur if the signal on Channel A or B is either interrupted or lost before the unit begins collecting data.

Stopped[Data acquisition failed]

Check both inputs and re-cycle the power button. If this message continues to appear, then call Timing Solutions Corporation and request technical support.

- **PRINTER FAULTS: the unit detects if a printer is either not connected or not turned on. However, it cannot detect if the printer is off-line in all situations.**



If this dialog box appears after PRINT is pressed, then check the printer connection and verify that the print is both turned on and on-line.

If the PRINT button is pressed and a printer is either not connected or not turned on, then a dialog box will appear on the screen. Press CANCEL to clear the fault.

IMPORTANT!

Printing is not queued. Printing must be completed before another screen can be printed.

You must also complete printing before PRINT is pressed, since the current data is lost when you start the next round of data collection

VII. Declaration of Conformity

Declaration of Conformity

According to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Timing Solutions Corporation

Manufacturer's Address: 4775 Walnut Drive Suite 1B
Boulder CO 80301
USA

Declares that the product:

Product Name: Time Interval Analyzer

Model Number: TSC 5110A

Product Options: All

Conforms to the following Product Specifications:

Safety:

EN61010-1:1993, Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use - Part 1: General Requirements

IEC 1010-1:1990, Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use, Part 1: General Requirements

EMC

EN61326:1997, Electrical Requirements for Electrical Equipment for Measurement, Control and Laboratory Use - Part 1: General Requirements

Supplementary Information:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly.

This product was tested in a typical configuration.

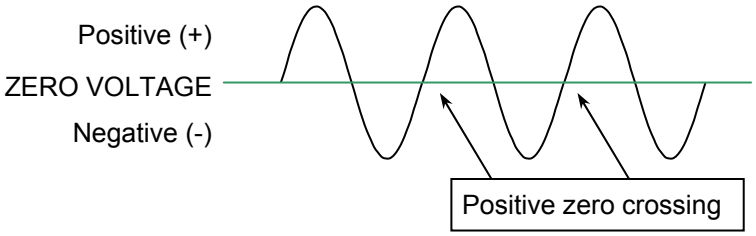
Boulder, CO April, 2002

VIII. GLOSSARY & INDEX

GLOSSARY

Adobe Acrobat Reader	A software program that enables people to read and print files saved in the .PDF format. It can be downloaded free from http://www.adobe.com/ and from our website: http://www.timing.com/
Allan Deviation	Square root of Allan Variance. In a set of sequential frequency measurements of an oscillator (or clock), the Allan deviation indicates the typical deviation from one measurement to the next.
Allan Variance	Two sample variance with no dead time.
CE	An Abbreviation for Conformite Europeenne. The CE marking indicates that the product conforms to all requirements that have been imposed on it by means of European directives, and that the product has been subject to the appropriate conformity assessment procedures.
DDS	Direct Digital Synthesizer
IEEE	The Institute of Electrical and Electronics Engineers
NCO	Numerically Controlled Oscillator
PCL	HP LaserJet printer language
PDF	Portable Document Format. File extension to be used by Adobe Acrobat Reader.

SSB	Single Side Band
Stable32	Third-party analysis software, more information can be found at: http://www.wriley.com
ZCD	Zero Crossing Detector
Zero Crossing	An oscillator generates an electric current, typically as a sine wave, that alternates between positive and negative values. The point where the voltage changes from positive to negative or negative to positive, where the voltage is zero, is the zero crossing. The point where it changes from negative to positive is the *positive* zero crossing.



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