



# **Advanced Measurement System**

## **RAM-5000-SNAP**

### ***User Guide***

Version 1.0.98 Rev.6

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


# Section 1

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*Instrument Overview*

# 1 Instrument Overview

This chapter provides an overview of the RAM-5000-SNAP instrument.

- Introduction  1-2
- Brief Description of Instrument Operation  1-3
- Instrument Control and Data Acquisition  1-4

## 1.1 Introduction

The RAM-5000-SNAP for the study of nonlinear acoustic phenomena (SNAP) is a state-of-the-art measurement system that features a broadband gated RF amplifier, unique tracking receiver, quadrature phase sensitive detectors, gated integrators and multiple frequency synthesizers. All controllable functions are programmable from an IBM-compatible computer that has been equipped with a proper interface card, typically a Sealevel PCI bus 8001 or 8010 card. The standard frequency ranges are from 50 kHz to 5 MHz or from 250 kHz to 7 MHz at up to 5 kW RMS output power (up to 30 MHz at reduced power). The various transmitter parameters and functions under computer control are: the frequency sent to each gated amplifier, the number of RF cycles within each high power RF burst, the RF pulse power, the delay for each high power RF pulse, the trigger source, and the internal repetition rate. The various receiver functions under computer control are the receiver frequency, the active receiver input, the receiver gain, the high and low pass filter settings in the broadband receiver, the receiver IF bandwidth, the video bandwidth, the integration time constant, and the integrator gate position and width. A software user interface allows for controlling these parameters, acquiring various types of data as well as making a number of specific acoustic measurements.

### ***Determining the Transmit and Receive Frequencies***

One of the main goals of the RAM-5000 unit is to make it possible to utilize a superheterodyne receiver for receiving signals which are different in frequency from the transmit burst, and at the same time preserve the phase information. This allows the use of quadrature phase sensitive detection, which is extremely valuable when the signal-to-noise ratio is poor. The frequency of the transmitted RF burst is determined by a gated synthesized frequency source. The receiver frequency is determined by setting a second synthesizer at the sum of the desired receive frequency and the intermediate frequency of the superheterodyne receiver. The phase relationship between these two synthesizers is established by turning them off and then simultaneously turning them on again with a zero degree phase relationship at the beginning of each RF burst.

A third synthesizer is also included when two transmit frequencies are employed, and the nonlinear property of the material is used to produce a difference frequency which can be received with a suitable transducer. Normally this requires two transmitter amplifiers, but under certain circumstances where the two frequencies are close, a single transducer can transmit two frequencies.

The general concept of these techniques is explained in the Brief Description of Operation



1-3 section.

### Detection Method

The system includes two phase-sensitive detectors (operating at the intermediate frequency) wherein the references are at the same frequency but shifted by ninety degrees with respect to each other. This allows the acquisition of the real and imaginary parts of the received signals. Gated integrators then act on a selected signal, and the resultant DC voltages are recorded by the computer (via the interface card previously mentioned) for measurement purposes.

### Making Multiple Frequency Measurements

The synthesizer supplied as an internal part of this RAM-5000 system is of the numerically controlled type. It yields direct digital synthesis of its output frequency. For the purposes of RAM programming it is essentially instantaneous in its ability to change frequency. Therefore, it is possible to acquire data at multiple frequencies (in a swept frequency mode, for example). Active gain switching of the receiver with Gallium Arsenide switches (rather than electro-mechanical relays) allows the programmer to change the gain as often as each repetition rate pulse to take into account changing signal levels at different frequencies.

## 1.2 Brief Description of Operation

The RAM-5000-SNAP system uses superheterodyne receiver circuitry similar to that used in standard radio receivers. A block diagram showing the arrangement used in radio transmission and reception is shown in Figure 1-1.

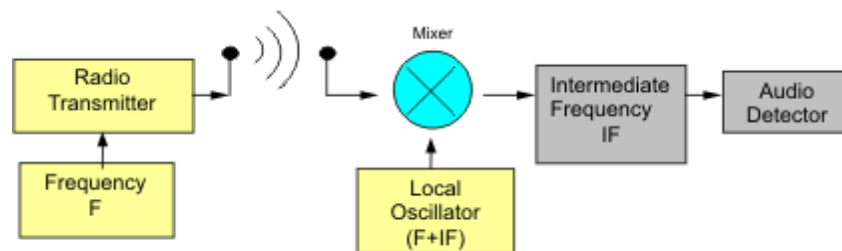


Figure 1-1. Superheterodyne Receiver.

When the operator tunes the radio receiver, he simply changes the frequency of the Local Oscillator (LO) until its frequency equals  $F + IF$ , where  $IF$  is the intermediate frequency of the receiver. This allows the use of narrow-band tuned  $IF$  amplifiers, which need only be adjusted once at the factory. The bandwidth of the system is also constant and independent of the operating frequency of the station. Note that two frequencies must be established: the transmitter frequency and the Local Oscillator frequency.

In the case of the RAM-5000-SNAP, three frequencies are required: the ultrasonic frequency,  $F$ ; the intermediate frequency reference,  $IF$ ; and the local oscillator frequency,  $LO$ . The  $IF$  reference is required, because phase sensitive detection is employed. Because it is a fixed frequency, a crystal oscillator may be used. It is, however, desirable to avoid adjusting

separately the ultrasonic frequency,  $F$ , and the local oscillator frequency, LO.

Synthesizer 3 is used to replace the local oscillator. The frequency of the synthesizer is referred to as the Local Oscillator (LO) frequency because it fulfills that function in the superheterodyne receiver.

The output of the Receiver Mixer contains two principal components, the sum frequency ( $(IF + F) + F = 2F + IF$ ) and the difference frequency ( $(IF + F) - F = IF$ ). If the same example for operation at 5 MHz is considered, it can be seen that, with synthesizer 3 set at 25 MHz, the sum component out of the Receiver Mixer is  $25 + 5 = 30$  MHz and the difference component is  $25 - 5 = 20$  MHz. The sum component at 30 MHz is rejected by the band-pass filter in the IF Amplifier while the difference component at 20 MHz (IF) is amplified and then coupled into the two phase sensitive detectors (multipliers). These are also driven by 0 degree and 90 degree outputs from the IF Oscillator at the correct reference frequency of 20 MHz. The video filters reject the sum frequency (40 MHz) output of the detectors, and the zero difference frequency (baseband) output contains the video information, which is sent to the integrators. This will then be true at any frequency within the operating range of the system, which is from below 100 kHz to above 20 MHz. (The operating range of the synthesizer 3 must then be from 20.1 MHz to 40 MHz to cover the full system range.) At very low operating frequencies, for example 0.1 MHz, both the sum and difference frequencies (20 and 20.2 MHz) will fall within the band-pass characteristics of the IF filter. When this occurs, ripples appear on the output signals from the phase detectors. Using heavier filtering in the video low pass filters can normally reduce these ripples. Fortunately, any residual ripple is averaged to zero in the Gated Integrators if they are operated in a normal fashion (gate slightly wider than the selected signal at the base line).

### 1.3 Control and Data Acquisition

The RAM-5000-SNAP is controlled entirely from a computer running Microsoft® Windows® 2000 or higher. The controls of a traditional instrument front panel are emulated via a software interface, which provides easy operation of and full control over all instrument settings as well as various data acquisition modes. In addition, the RAM-5000-SNAP may be programmed and operated from National Instruments LabVIEW™ via a control and data acquisition VI library.

# Section 2

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*Getting Started*

## 2 Getting Started

This chapter describes details necessary to place the RAM-5000-SNAP system into operation.

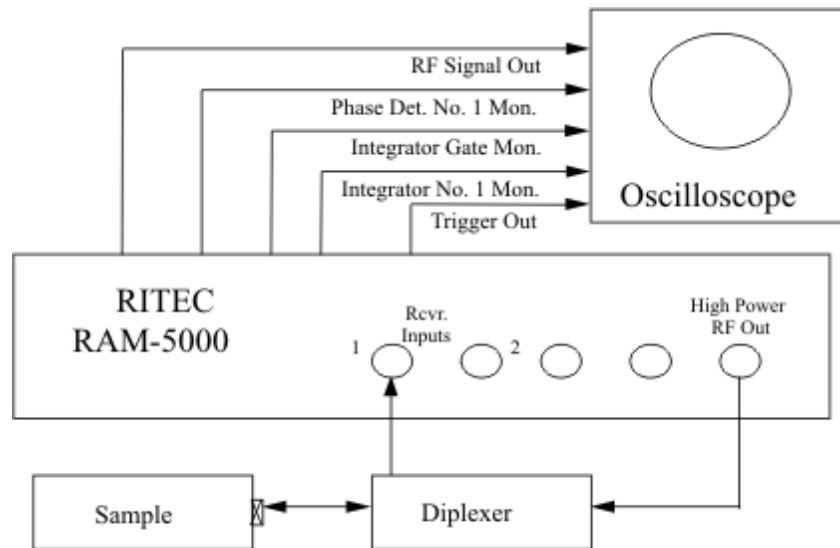


Figure 2-1. Typical RAM connection diagram.

Besides cabling the system for normal operation as shown in Figure 2-1, it will also be necessary to make use of the many monitor points provided on the front and rear panels of the instrument. For example, the "RECEIVER RF MONITOR" on the front panel provides a received signal, which is 20 dB (into 50 Ohms) below the signal level introduced into the Receiver Mixer. This signal is of great value in tuning the system.

For the entire list of signal connectors and monitor points, which may be used at various stages of establishing operating conditions for the system, please see the section on Instrument Connectors [11-2].

The following sections provide step-by-step guides:

- Step-by-Step Installation Procedure [2-2]
- Preliminary Measurement Setup [2-3]

### 2.1 Step-by-Step Installation Procedure

The following step-by-step procedure will aid in placing the equipment into successful operation.

Interconnect the RAM-5000-SNAP and an IBM PC (or equivalent) computer equipped with an appropriate interface card (typically Sealevel 8001 or 8010), and a wide band oscilloscope as follows:

1. Install the Sealevel drivers.
2. Computer cable from the interface card (in the computer) to the computer connector on the rear panel of the RAM-5000-SNAP.
3. BNC cable from "Trigger Out" (11-8) (rear of RAM) to Trigger In on oscilloscope.
4. BNC cable from "R.F. Pulse Monitor" (11-2) (front of RAM) to 50 Ohm input on oscilloscope.
5. BNC cable from "Phase Det. No.1 Mon." (11-5) (rear of RAM) to second input on oscilloscope (high impedance).
6. BNC cable from the "High-Power RF Pulse Out" (11-2) to a Signal Diplexer input ("IN" on a RITEC RDX-6)
7. BNC cable from the Diplexer "OUT" to the transducer and sample.
8. BNC cable from Diplexer "TO REC." to "Receiver Input No.1" (11-3) on the RAM.
9. If a pre-amplifier is to be used, it should be inserted between the Diplexer "to Rec." and the RAM receiver input.
10. To simplify the operation of the system and to eliminate the need to frequently change cable positions the RITEC RS-5 Signal Sampler is available as an accessory. All normally used signal monitor points are brought to a pair of five position selector switches. The outputs of the switches are then brought to a pair of BNC connectors for connection to the vertical inputs of an oscilloscope. The coherent trigger output is brought directly to a "Trigger" BNC connector. When switched to the "RF Pulse Monitor" (11-2) or "RF Signal Out" (11-3), the outputs are automatically terminated in the proper 50 Ohms. Complete operating instructions are provided with the RS-5.

***The system is now cabled and is ready for operation.***

## 2.2 Preliminary Measurement Setup

It will be necessary to program various functions from the computer in order to successfully implement this initial operation. Refer to the section of this manual describing the programming technique then proceed as follows:

1. Turn on the "Power" switch on the RAM-5000-SNAP and computer.
2. Start the software user interface already installed on the computer.

3. Program the RF Gain<sup>[5-3]</sup> for approximately 40 dB (Receiver Setup).
4. Program the IF Bandwidth<sup>[5-7]</sup> for 4 MHz (Receiver Setup).
5. Program the synthesizer for the desired operating frequency. (Source Setup)
6. Set the Gated Amplifier Output Level<sup>[4-8]</sup> to 10 which will yield an output of approximately 144 Vpp. See calibration chart at the end of the RAM-5000-SNAP manual.
7. Program the pulse width of the Gated Amplifier (either in cycles of the RF pulse or in microseconds) for the desired output.
8. Turn on the "High Voltage" and check the oscilloscope for an RF pulse from "RF Pulse Monitor". This will allow an examination of both the amplitude of the RF driving pulse (approximately 100 times the oscilloscope reading) and the width of the pulse. The frequency within the pulse can also be roughly measured to be sure that it corresponds to the desired operating frequency.
9. Reconnect the cable to the oscilloscope (from step 8) to the "RF Signal Out" monitor on the RAM. This will permit observation of amplified RF signals from the sample.
10. Next, proceed with fine-tuning the frequency to optimize the received signals. Observing the "RF Signal Out" monitor on the front panel (using a 50 Ohm oscilloscope input) will be useful when carrying out this process. Once a small signal has been obtained, the frequency can be easily optimized. The signals appearing at this point should not exceed 100 mV peak-to-peak to insure that operation is within the linear range of all stages of the receiver. If the signal is too large, reduce the receiver gain until the signal falls within its maximum value.

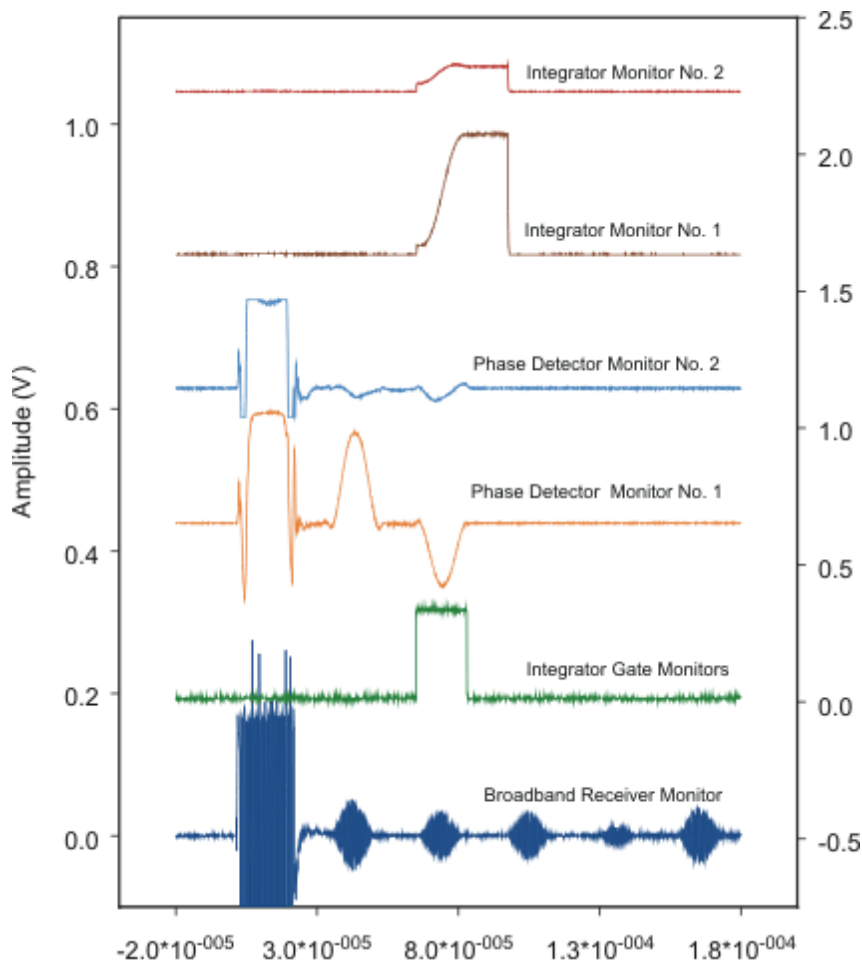


Figure 2-2. Receiver Monitors.

11. While observing one of the "Phase Detector Mon. -20 dB" test points (using a high impedance oscilloscope input), set the oscilloscope sensitivity at 100 mV/cm. Check that an in-phase condition exists by changing the frequency of Synthesizer No. 1 in very small steps. If the gain has been set properly in step 10, the signal should not exceed +/-200 mV for an in-phase signal. A typical waveform is shown in Figure 2-3.

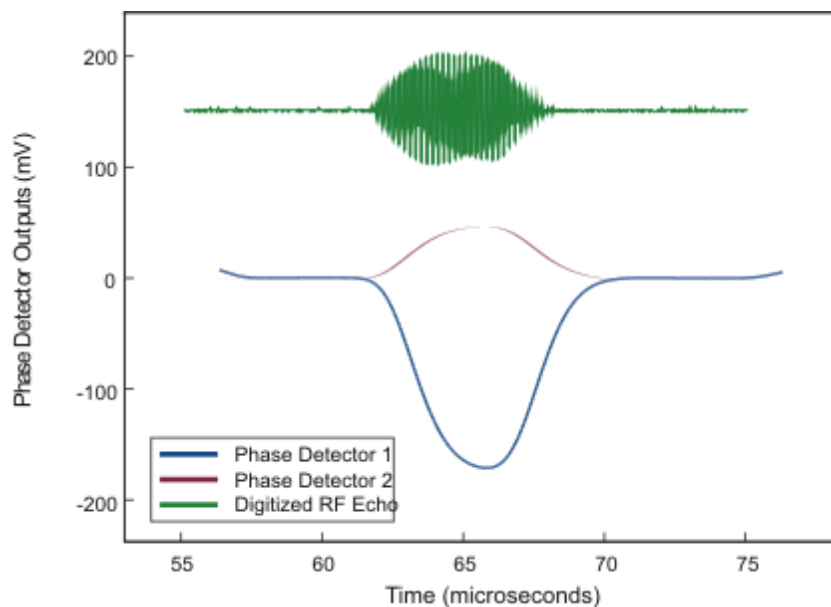


Figure 2-3. Typical Phase Sensitive Detector Output.

12. Next, program the video low-pass filters for maximum bandwidth. The video filters may then be progressively programmed to lower bandwidths until the signals just begin to degrade. The integrators in most situations are more effective than the video filters in removing noise and they do so without distorting the phase or stretching the signals in time. It is, therefore, a good idea to take data with less filtering than would normally be chosen by observing the oscilloscope. When in doubt, take data with the low-pass video filters set at the highest cut-off frequency (2 MHz).
13. The integrator gate may now be positioned over the echo to be examined. The position and width of the gate can be observed from the "Integrator Gate Mon." connector on the rear panel. The gate should completely encompass the signal to be measured. Use a 50 Ohm termination (or a Ritec RS-5 Signal Selector) so that a faithful reproduction of the gate is provided.
14. Install a cable from the "Integrator No. 1 Mon." to a high impedance input on the oscilloscope with the sensitivity at 200 mV/cm and D.C. coupled. A waveform resembling that shown in Figure 2-4 should be observed. Note that a positive going phase detected signal will produce a negative output from the integrator.



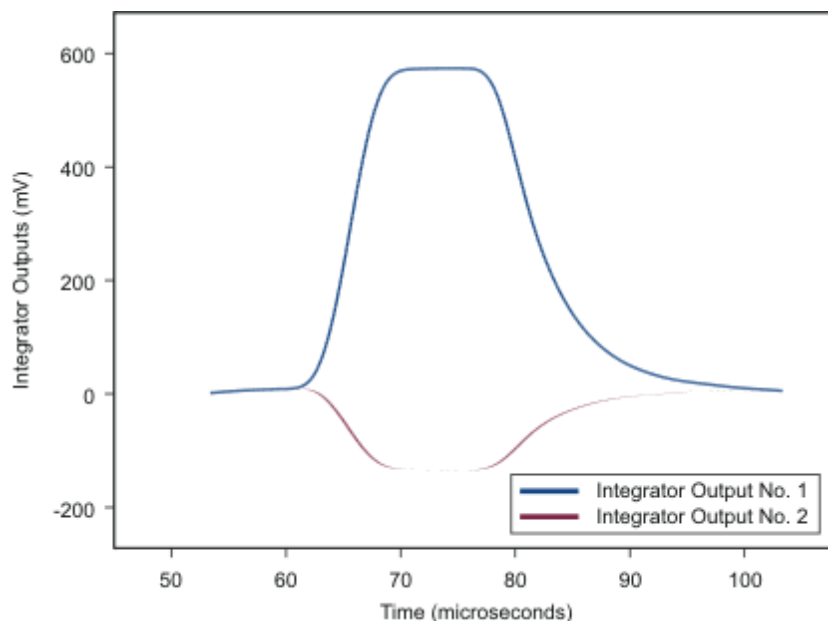


Figure 2-4. Typical Integrator Output.

15. If the maximum deflection is greater than 400 mV, program the next lower integration rate. Continue until the maximum signal is approximately 400 mV (which corresponds to 4 V within the RAM). If the maximum integrated value (at the monitor point) is significantly less than 200 mV, try the next larger integration rate. Sixteen time constants are available. The signal out of the integrator is converted to a digital value by the sixteen bit analog-to-digital converters built into the RAM, and this digital value is then transferred to the computer via the interface card. Do not be concerned if the maximum output at the phase detector monitor slightly exceeds 200 mV because there is sufficient headroom in all the amplifiers in the system to allow at least a 10% over amplitude condition. This is not true for the output of the S & H signal that is transferred to the A/D in the interface card. In this case an absolute maximum of +/-5 Volts (including DC offsets) must be observed. Note that a positive phase detected signal will produce a negative integrator signal.
16. Finally, use the computer to change the phase reference by 180 degrees. The integrated waveform should now be positive. When actually making measurements, the phase is flipped back and forth repeatedly to allow removal of DC offsets from interfering with measurements.

***This completes the preliminary measurement setup.***

# Section 3

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*User Interface*

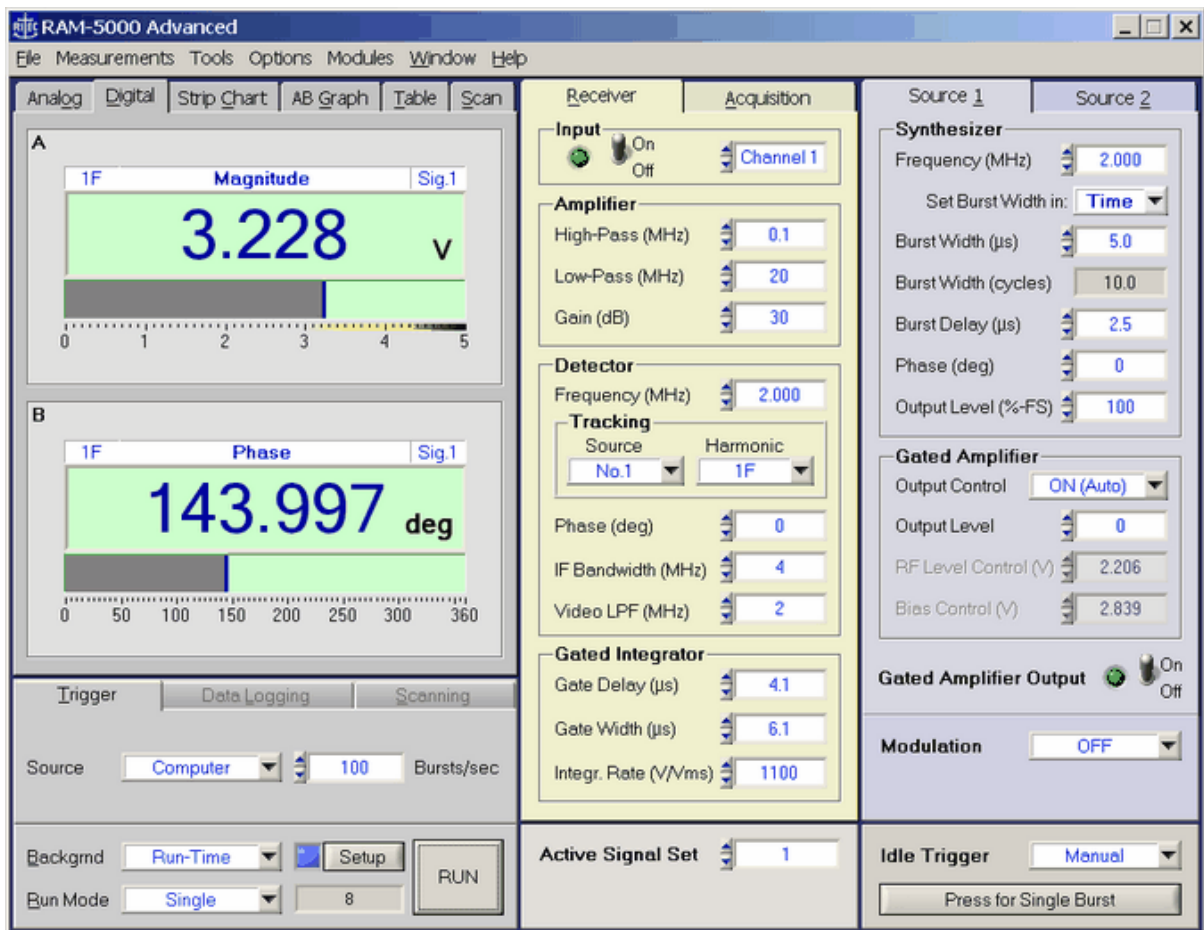
### 3 User Interface

This chapter provides an overview and describes general features of the software user interface to control the RAM-5000-SNAP instrument.

- Overview [3-2](#)
- Main Menu [3-4](#)
- Setting Preferences [3-10](#)
- Controlling Instrument Parameters [3-14](#)

#### 3.1 Overview

The RAM-5000-SNAP is controlled entirely from a computer running Microsoft® Windows® XP or higher. The controls of a traditional instrument front panel are emulated via a software user interface. The RAM-5000-SNAP user interface provides full control over all instrument operation parameters and features powerful data acquisition and sophisticated data display options.



The RAM-5000-SNAP User Interface in its default layout.

The layout of the instrument controls was designed to be similar to that of a typical instrument's hardware front panel. The controls are organized according to the instrument configuration and analog signal processing flow, and the locations of the actual instrument front panel connectors. Thus, the RAM-5000-SNAP user interface exhibits a right-to-left, top-down control and signal flow. The User Interface consists of three horizontally arranged main sections. One primarily comprises everything controlling signal generation, a second comprises all controls for signal detection as well as acquisition options, and a third comprises all of the data acquisition main controls and data visualization and analysis options.

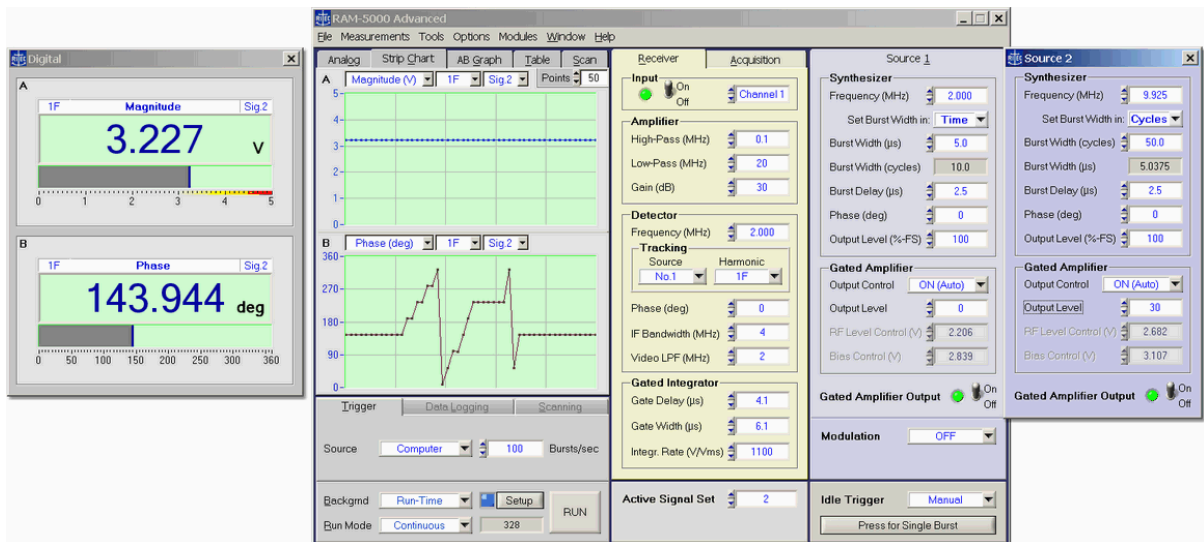
On the right side of the User Interface main panel, there are two tabs with controls for each Pulse Source [4-2](#). Near the bottom end of these tabs, there is a common extension with controls for enabling and setting up Modulation [4-10](#). Below this, there is a small and separate panel with controls for the Idle Trigger [4-27](#).

In the mid-section, there is a second pair of tabs, one with controls for the Receiver [5-2](#) and the other for setting various Acquisition Options [6-23](#).

On the left, there are tabs for displaying acquired data in several different ways. The user may choose to examine various types of measurement data using a pair of Analog Gauges [7-2](#) or Digital Gauges [7-4](#), a pair of synchronized Strip Charts [7-6](#), a Channel A versus Channel B Graph [7-9](#), a multi-purpose Data Table [7-12](#), as well as a Scan Graph [7-14](#) for viewing and analyzing data acquisition scans. Below this, there is a separate panel for setting up and controlling data acquisition [6-3](#).

To make a particular set of controls visible, simply click on their tab. Each of these tabs may also be selected via the short cut key assigned to a tab. The short cut consists of the key combination <Alt> + the letter or number that is underlined in the tab's label, as in 'R' for Receiver.

The RAM-5000-SNAP user interface, as shown above, may also be customized to better suit your particular needs. That is, most of the tabs, may be detached from the main panel. To detach a tab and convert it into a freely moving panel, right-click the mouse pointer on the tab label and select the detach option from the generated popup menu. To re-attach a panel, simply close the panel, which will convert it back into a tab on the main panel. Whatever organization you may prefer, it is saved and will be fully restored automatically upon restarting the user interface software.



The RAM-5000-SNAP User Interface in one of many different customized layouts.

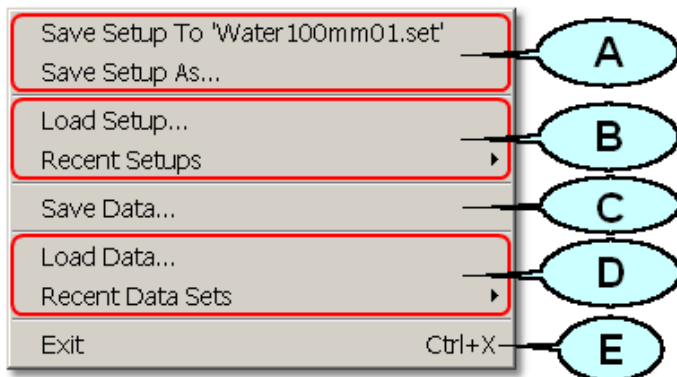
## 3.2 Main Menu



The main menu, located at the top of the RAM-5000-SNAP user interface, provides access to a series of named submenus. Each of these submenus are described individually:

- File [3-5](#)
- Measurements [3-6](#)
- Tools [3-7](#)
- Options [3-8](#)
- Window [3-8](#)
- Help [3-10](#)

### 3.2.1 File



#### *Saving the current instrument setup (A)*

**Save Setup To** saves the setup to the file as named between the single quotes, as in '*Water100mm01.set*'. The file name dynamically changes and reflects the most recently opened setup file for loading or saving the instrument setup. This menu item provides a fast and convenient method to save the current (and possibly changed) setup to the same file. This option is equivalent to the common **Save** command found in many software applications. After launching the RAM-5000-SNAP User Interface, this menu item will be dimmed and not show any filename, since a customized instrument setup has not yet been loaded or saved.

**Save Setup As...** opens a file/folder browser to save the current instrument setup to a specific folder and possibly under a new name.

#### *Loading an instrument setup (B)*

**Load Setup...** opens a file/folder browser to load a previously saved instrument setup from a specific folder.

**Recent Setups** opens a submenu with a list of up to nine most recent previously saved (and newly named) instrument setups for quick loading.

#### *Saving a scan data set (C)*

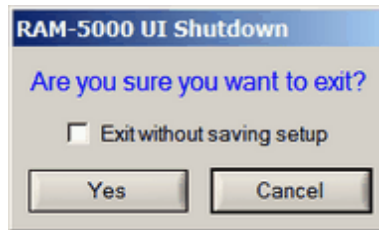
**Save Data...** opens a file/folder browser to save the current scan data to a specific folder and possibly under a new name.

#### *Loading a scan data set (D)*

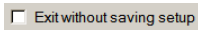
**Load Data...** opens a file/folder browser to load a previously acquired and saved data set from a specific folder.

**Recent Data Sets** opens a submenu with a list of up to nine most recent previously acquired and saved data sets for quick loading. That is, no file browsing is necessary.

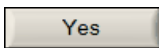
### Shutting down the RAM-5000-SNAP User Interface (E)



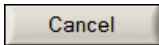
**Exit**, opens a confirmation dialog with the following options:



Selecting this option causes the current instrument setup and user interface settings to be discarded upon exiting. Leaving this option in the *unselected* state assures that the next time you launch the User Interface, all customized settings are reproduced. Whereas, selecting this option will cause the RAM-5000-SNAP User Interface to reuse the settings that were last saved when exiting normally.

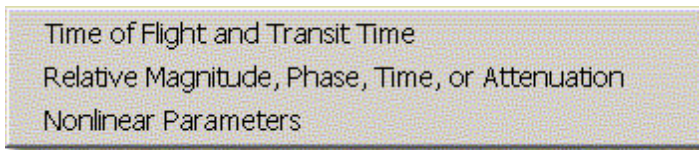


...proceed shutting down the User Interface. If the option "Exit without saving setup" was left in the unselected (default) state, the RAM-5000-SNAP User Interface automatically saves the current instrument setup and user interface settings before exiting.



...abort shutting down the User Interface.

### 3.2.2 Measurements



This menu provides access to various types of simple measurements.

A simple measurement typically consists of selecting a certain predefined parameter, such as a particular ratio or difference, which is then calculated on-the-fly from raw data acquired under specific conditions. The measurement parameter value is immediately made available in the User Interface as an additional Data View <sup>7-17</sup> in all of the gauges and graphs. If data logging is enabled, the measurement value is also saved as an additional column in the log file, and similarly for scanned data acquisition.

Some measurements may, in addition to the above, also involve a series of automated data processing steps. Typically, this would be referred to as a *measurement procedure*. It consists of first configuring and executing a particular scan. The scan is automatically followed by a predefined sequence of data analysis steps, that are performed on the entire

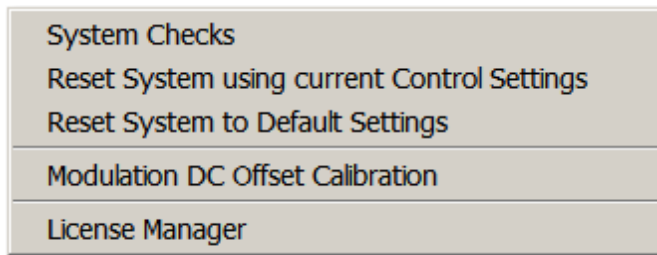
data set, resulting in one or more final measurement values.

The measurements presently implemented, include:

- Time of Flight and Transit Time [8-2](#)
- Relative Magnitude, Phase, Time, or Attenuation [8-6](#)
- Nonlinear Parameters [8-10](#)

**Note:** The measurements listed above are by no means representative of the full spectrum of measurement capabilities. In fact, a fully equipped RAM-5000-SNAP (especially if it includes two Gated Amplifiers and the Modulation [4-10](#) module), may be used for a wide variety of measurement scenarios. A number of additional measurements may be performed, simply by defining and executing one of the many possible Scan [6-8](#) configurations to acquire raw data, which may then be processed in an appropriate third-party software application. In addition, the user may elect to write custom measurements and procedures using the included API Function Library.

### 3.2.3 Tools



This menu provides access to various tools including a number of System Checks [12-2](#) that may be executed to verify that the RAM-5000-SNAP is working properly.

**Reset System using current Control Settings** re-initializes the instrument using the active RAM-5000 system control parameters. Selecting this menu item is useful, for example, when your system lost power while the RAM-5000-SNAP User Interface was still running, or when you are simply not sure about the current control programming state of the instrument.

**Reset System to Default Settings** initiates a complete reset of the RAM-5000 system. This will return all system control parameters to their default settings and re-initialize the instrument accordingly. The execution of this procedure may be useful if you want to restart with the default instrument setup. The system control Preferences [3-10](#) settings are not affected by this reset (see Options Menu [3-8](#) for resetting the User Interface).

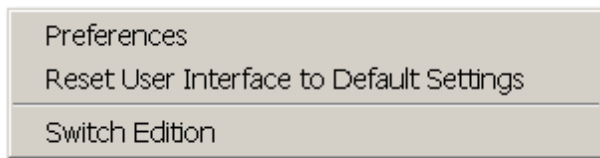
**Modulation DC Offset Calibration** [4-25](#) opens a dialog from which you can initiate a fully automated procedure for calibrating the DC Offset control [4-24](#), as needed.

**License Manager** opens a dialog which you use to register and properly configure the



various software and hardware components of your particular RAM-5000 system.

### 3.2.4 Options

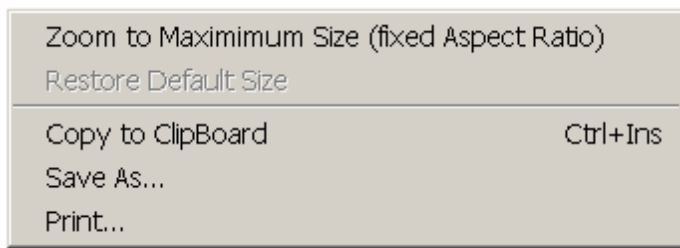


This menu includes a number of software configuration options. The item Preferences <sup>3-10</sup> opens up a dialog window for setting a number of options for the User Interface, data formats, etc.

From the Options Menu, you may also initiate a complete reset of the RAM-5000-SNAP user interface. Selecting the menu item **Reset User Interface to Default Settings** will return all user interface preferences to their default settings and re-initialize the User Interface. The execution of this procedure may be useful if you want to restart with the default user interface configuration. The *instrument* control settings are not affected by this reset (see Tools Menu <sup>3-7</sup> for resetting only the instrument).

If available, selecting the menu item **Switch Edition** saves the current user interface settings, then restarts the User Interface in its alternate edition. That is, if you are currently running the **Advanced Edition**, it will switch to the **Standard Edition**, and vice versa. *This option is mainly used during system/software evaluation.* However, it may also be useful if a simpler system operation is desired on a temporary basis, for example, for the purpose of learning basic operations.

### 3.2.5 Window



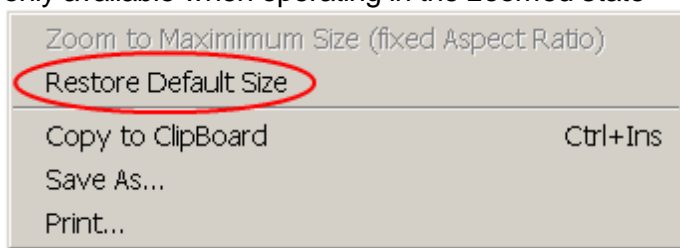
This menu contains items that control the size of the RAM-5000-SNAP user interface display. In addition, the Window Menu provides various options that allow you to create a bitmap image of the present display of the main window.

**Zoom to Maximum Size** scales the main window to a size that attempts to match the

computer monitor screen while preserving the aspect ratio of the window. Secondary dialog windows presently open or that will be opened at a later time are all automatically scaled by the corresponding zoom factor. If the User Interface has been customized by detaching a tab <sup>3-3</sup> from the main panel, the corresponding panel will be automatically converted back to a tab.

**Note:** Detaching tabs from the main panel to customize the User Interface is not allowed while it is *zoomed to maximum size*.

**Restore Default Size** scales the User Interface, including all user interface elements, back to it's default size, which has been designed for a display resolution of 1024x768 pixels or larger. If the User Interface was customized (by detaching a tab), this customization will also be restored automatically (unless the User Interface has been reset <sup>3-8</sup>). This menu item is only available when operating in the zoomed state



**Copy to Clipboard** creates a bitmap image of the main window (*without the frame and titlebar*) and copies the image to the computer clipboard.

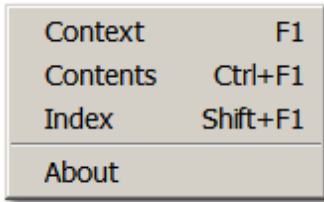
**Save As...** creates a bitmap image of the main window (*without the frame and titlebar*) and opens a file/folder browser for you to save the image to a specific folder under a user-defined filename. You may choose between four different image file formats:

- \*.PNG --- PNG Bitmap (LZ77 Compression)
- \*.JPG --- JPEG Bitmap (90% Quality, Progressive/Interlaced)
- \*.TIF --- TIFF Bitmap (RLE Compression)
- \*.BMP --- Windows Bitmap (Uncompressed)

When specifying the filename, the appropriate file extension must be added (not case-sensitive), or the image format will default to a Windows Bitmap. The same applies, if some other extension is added. The available image formats are ordered by resulting file size, starting with the smallest.

**Print...** creates a bitmap image of the main window (*without the frame and titlebar*) and opens a Print Options dialog for you to send the image to a printer. In an effort to conserve ink, the background color temporarily changes to white.

### 3.2.6 Help



The Help Menu provides access to various types of information related to the RAM-5000-SNAP hardware and the installed software components.


**Context** opens the RAM-5000-SNAP Help viewer with help specific to the control or panel that was last activated or selected.

**Contents** opens the RAM-5000-SNAP Help viewer with the Table of Contents (TOC) visible, the TOC tree collapsed, and shows the introductory help topic.

**Index** opens the RAM-5000-SNAP Help viewer with the Index visible, and shows the introductory help topic.



**About** reopens the splash (program start) window with information about the installed software components, the software license data, and the hardware, such as the serial number.

### 3.3 Setting Preferences

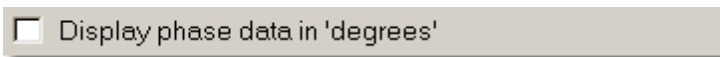
The RAM-5000-SNAP User Interface allows for setting a number of preferences, pertaining to the user interface itself, or various instrument control and data acquisition settings. The preferences dialog panel may be opened from the Options  menu, and contains tabs



, each for a particular group of settings.

- User Interface Preferences  [3-10](#)
- General Preferences  [3-13](#)


#### 3.3.1 User Interface




Enabling this option, the RAM-5000-SNAP User Interface always converts the phase data into

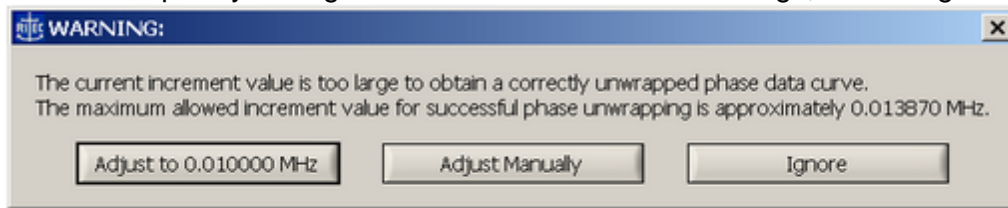
degrees for display in any of the gauges (meters, charts, and the AB graph) as well as the scan graph. Regardless of how the phase data is being saved by the User Interface, you will always be able to view the phase data on any display in the unit *degrees*.

Display unwrapped phase data (scanned acquisitions)

If this option is enabled (the default setting), the RAM-5000-SNAP User Interface always tries to unwrap (by resolving 2p jumps) the phase data from a scanned acquisition before displaying it on the scan graph. Regardless of how the phase data is being saved by the User Interface, the scan graph always shows the same data in their unwrapped form. In most cases, this option should be left enabled, especially if Time of Flight and Transit Time measurements  are to be performed.

Check scan frequency increment for phase unwrapping

If this option is enabled (the default setting), the RAM-5000-SNAP User Interface validates the frequency *Increment* value that you specify (maybe indirectly by specifying the *Points* value instead) on the Scanning  tab, when setting up a Frequency Scan. For successful phase unwrapping (resolving 2p jumps) to be possible, the frequency scan increment (step size) must not be larger than a certain threshold value which depends upon the integrator gate and detector frequency settings. If the *Increment* value is too large, a message dialog box



with three options will be shown. Selecting either option (clicking the respective button) closes the message box and then does the following:



...automatically adjusts the current *Increment* value for you to the one being suggested in the button label, for example 0.01 MHz. Selecting this option assures that the frequency scan increment will be sufficiently small for successful phase unwrapping to be possible, while using a reasonable value to obtain well-defined (none being "odd" numbered, as the maximum allowed usually is) operating frequencies in the course of a scan.




...allows you adjust the frequency *Increment* value manually. This option may be useful if the suggested value does not suit your needs.



...allows you to continue with the present frequency *Increment* value.

**Note:** The message dialog box shown above may also appear when starting a frequency scan and either the integrator gate settings or the detector frequency setting have been changed since specifying the frequency *Increment* value.

Enable instrument panel scrolling and resizing

Enabling this option adds a horizontal and a vertical scroll bar to the main window of the RAM-5000-SNAP User Interface. The main window may be resized using the mouse without scaling the interior of the window. This option is useful when several windows are to be arranged side-by-side on the computer monitor screen. Enabling this option requires a much smaller screen area without reducing the size of any instrument controls. Using the scroll bars, a particular panel of interest is simply scrolled in and out of the visible region (similar to a view port) of the instrument panel. For example, the entire instrument panel may be reduced to the size of the Data Acquisition and Display section or just the Receiver panel. This option may be used, whether the main window is zoomed to maximum size  or not. Disabling this option automatically restores the full size of the previous configuration (default or maximized).

 Confine panels within screen area when moved

Enabling this option keeps any freely moving panel that belongs to the RAM-5000-SNAP User Interface within the visible region of the computer monitor screen. This includes detached tabs/panels and any add-on module user interface windows.

 Enable panel activation via mouse hover

Enabling this option makes each freely moving panel that belongs to the RAM-5000-SNAP User Interface sensitive to mouse pointer movements. Each window that the mouse pointer moves over (hovers) will be immediately brought into the foreground, thereby activating it and making it ready for user input. This includes detached tabs/panels and any add-on module user interface windows.

 Prompt for filename at start of scan

If this option is enabled (the default setting), the RAM-5000-SNAP User Interface will prompt you at the start of a scan to specify a filename. The software saves the acquired data immediately to a *named* data file while scanning. If this option is disabled, the software instead writes the acquired data to temporary file(s) for backup during the scan and prompts you for a filename at a later time, when the data in memory is about to be discarded. This will occur, when a new scan is initiated, or when the instrument setup has changed and no longer properly reflects the system configuration with which the data was acquired. Once the data are saved to a *named* file, the backup file(s) are automatically deleted. As long as no new scan has been performed, the backup file(s) (lastScan.\*), will remain intact and may be found in the program folder of the RAM-5000-SNAP software installation, even after exiting and restarting the User Interface.

### 3.3.2 General

Save phase data in 'degrees'

Enabling this option, the RAM-5000-SNAP User Interface converts the phase data into degrees before saving. Regardless of how the phase data is being viewed inside the software, any data file will store the same data in the unit degrees.

Save unwrapped phase data (scanned acquisitions)

Enabling this option, the RAM-5000-SNAP User Interface tries to unwrap (by resolving 2pi jumps) the phase data from a scanned acquisition before saving. Regardless of how the phase data is being viewed inside the software, any data file will store the same data in their unwrapped from.

Save standard deviation data

Enabling this option, the RAM-5000-SNAP User Interface calculates the standard deviation and stores it along with the main data (integrator A/D channel no.1 and 2 voltages, magnitude, phase, and auxiliary A/D channel no.1 and/or channel no.2 voltages) in a log or scan data file, when using Mean Averaging<sup>[6-25]</sup>. The standard deviation of the integrator and auxiliary channel data is calculated as the *Sample Standard Deviation*, which is defined by

$$\sigma_{Sample} = \sqrt{\frac{1}{N_{AVE} - 1} \sum_{i=1}^{N_{AVE}} (V_i - \bar{V})^2},$$

where  $N_{AVE}$  is the averaging count,  $\{V_i\}$  is the data sample, and  $\bar{V}$  "bar" is the mean of this sample. The standard deviations of the magnitude and phase data are calculated using the equations,

$$\sigma_{Magnitude} = \frac{\sqrt{\left(\overline{V_{IntegratorNo.1}} \cdot \sigma_{IntegratorNo.1}\right)^2 + \left(\overline{V_{IntegratorNo.2}} \cdot \sigma_{IntegratorNo.2}\right)^2}}{\overline{V_{Magnitude}}}$$

and

$$\sigma_{Phase} = \frac{\sqrt{\left(\overline{V_{IntegratorNo.2}} \cdot \sigma_{IntegratorNo.1}\right)^2 + \left(\overline{V_{IntegratorNo.1}} \cdot \sigma_{IntegratorNo.2}\right)^2}}{\left(\overline{V_{Magnitude}}\right)^2},$$

which have been derived using the *Propagation of Uncertainties* method to consider the integrator data uncertainties ( $\sigma_{Integrator}$ ) in the definitions of the magnitude and the phase.

## 3.4 Controlling Instrument Parameters

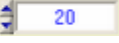

All instrument parameters can be controlled via *menu* or *numeric* user interface controls. A menu control [3-14](#) is used when the instrument parameter may be set to a limited number of specific options, such as filter settings. A numeric control [3-14](#) is used when the instrument parameter may be set to a wide range of values, such as burst frequency. Numeric controls with floating point values, in most cases, also allow you to customize a Step Size [3-15](#) value.

For controlling specific instrument parameters, select the appropriate link below.

- Signal Generation [4-2](#)
- Signal Detection [5-2](#)


### 3.4.1 Menu Controls

This type of control allows you to select an instrument parameter setting from a limited number of options. When you click on these controls with the mouse pointer, a popup menu will list the available options/settings for that control.

If the settings involve numerical values, a pair of small up and down arrow buttons, located on the left side of the control , allows for stepping through the available choices. If the settings involve labels, such as *Manual*, *Computer*, and so on, the control has a single down arrow button on its right side . In both cases, you may also step through the available choices of each control by using the up and down arrow keys on the keyboard once that control has been activated.

**Note:** An activated or selected menu control is typically marked by one or more indicators. If the control has a descriptive text label, e.g. “Trigger”, this label will be surrounded by a dotted rectangle. If there is no label, the control itself will be outlined by a dotted rectangle. An unselected control can be activated without immediately changing its value, by left-clicking on its label using the mouse pointer, or by ‘tabbing’ to it via the Tab or Shift+Tab keys.

### 3.4.2 Numeric Controls

This type of control allows you to set an instrument parameter by editing its numeric value within certain limits. A numeric control  value can be edited by moving the mouse pointer over the edit field of the control (mouse pointer should change into a text edit cursor), and then clicking the left mouse button. To enter a number in the edit field, first position the cursor, then type the desired value. Scientific notations, such as 5e-2, can also be used and will be converted to floating point format, as in 0.05.

**Note:** To make sure the new parameter setting is programmed into the instrument, hit the Enter key or left-click the mouse pointer on the control's text label, immediately after editing its value.

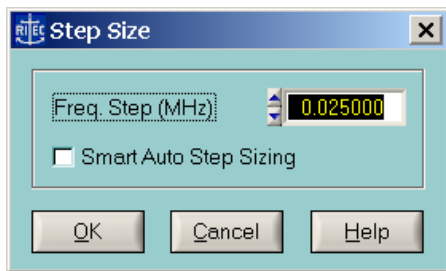
A pair of small arrow buttons located on the left side of the control, allows for stepping the numeric value up and down by a preset step size value. You may also change the value of a control by using the up and down arrow keys on the keyboard once the control has been activated.

**Note:** An activated or selected numeric control is typically marked by one or more indicators. If the control has a descriptive text label, e.g. "Frequency (MHz)", this label will be surrounded by a dotted rectangle. If there is no label, the control itself will be outlined by a dotted rectangle. An unselected control can be activated without immediately changing its value, by left-clicking on its label using the mouse pointer, or by 'tabbing' to it via the Tab or Shift+Tab keys.

The step size value setting for a particular numeric control is either handled automatically by the RAM-5000-SNAP User Interface, or you may customize it. To customize use the step size control<sup>3-15</sup> dialog that is accessible by right-clicking the mouse pointer over a numeric instrument control, and then select **Step Size...** from the context menu. Or, when you select **Enable Smart Auto Step Sizing** from the context menu the step size value is determined by the RAM-5000-SNAP User Interface, based on control value keyboard input (see Smart Auto Step Sizing<sup>3-16</sup> for more information).

**Note:** Not all numeric controls have a customizable step size value.

### 3.4.3 Step Size Control



*Step Size dialog for frequency controls.*



This dialog allows you to customize the *Step Size* that is used for changing the value of a particular numeric instrument control. This *Step Size* is only applicable when modifying the value via the up and down arrow buttons and keys. Each control maintains its own step size value.

You also can enable the option *Smart Auto Step Sizing* which controls whether the RAM-5000-SNAP User Interface uses your keyboard input, that is when entering the value for a particular instrument control parameter via the keyboard, to manipulate the active step size



value on the fly.

The following topics describe the available Step Size options:

- Manually Setting  3-16
- Smart Auto-Sizing  3-16

### 3.4.3.1 Manually Setting

This option allows you to specify any Step Size value within the range of the particular numeric control.

The value entered in the edit field, is validated with respect to the minimum and maximum step size values for each control, before being stored as the new Step Size for that selected instrument control. To determine the smallest possible step size, enter the value "0". Similarly, to determine the largest possible step size, enter a value on the order of the upper limit of the instrument control itself.

**Note:** The pair of small arrow buttons located on the left side of the step size control edit field, allows for stepping the numeric value up and down by the smallest possible step size value for the selected instrument control.

### 3.4.3.2 Smart Auto-Sizing

With this option enabled, the step size value will be deduced (and automatically updated) from the value that you enter into an edit field of a numeric control. Specifically, if the last (non-zero) digit reads 1, 3, 7, or 9, the step size will become 1, whereas, if the last digit reads 2, 4, 6, or 8, the step size will be a 2 at this particular digit position. Otherwise, the last digit will become the new step size value, that is, in the case of a 5.

**Tip:** For quick access to the enable state of this option, you can check the context menu that is accessible by right-clicking the mouse pointer over a numeric instrument control. If you see the item **Enable Smart Auto Step Sizing** the option is currently disabled. Likewise, if you see the item **Disable Smart Auto Step Sizing** the option is currently enabled.

# Section 4

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*Signal Generation*

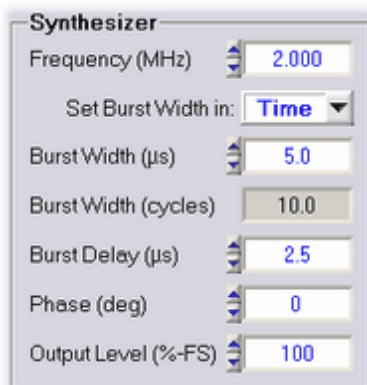
## 4 Signal Generation

This section describes the controls that are located on a Source tab and on the Trigger panel of the RAM-5000-SNAP User Interface.

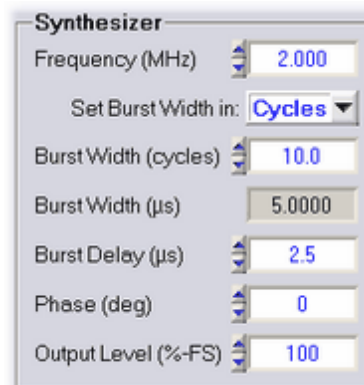
- Synthesizer <sup>4-2</sup> - Frequency, Burst Width and Delay, Phase, and Output Level
- Gated Amplifier <sup>4-6</sup> - Output Control and Level, RF Level and Bias Controls
- Output Enable <sup>4-9</sup>
- Modulator <sup>4-10</sup> - Modulation Type, Amplitude, and DC Offset
- Trigger <sup>4-21</sup> - Source Control and Rep-Rate

**Note:** Throughout the RAM-5000-SNAP documentation, the term *burst* is used interchangeably with the term *pulse* and refers to the same type of signal, although strictly speaking, a *burst* is typically considered a narrowband time-limited signal, whereas a *pulse* is a time-limited signal that may contain any number of frequencies.

### 4.1 Synthesizer




The Synthesizer controls when setting the Burst Width in time.




The Synthesizer controls when setting the Burst Width in cycles.

Each Synthesizer of the RAM-5000-SNAP Pulse Source setup has the following control options:


- Frequency <sup>4-3</sup>
- Burst Width <sup>4-3</sup>
- Burst Delay <sup>4-5</sup>
- Phase <sup>4-5</sup>


- Output Level 

#### 4.1.1 Frequency

*Nominal range: 0.2 to 30 MHz in 1-Hz steps. For the range of your RAM-5000-SNAP refer to the **Specifications** in the Appendices .*


This control  is for setting the burst frequency of the respective source.



**Note:** Changing the burst frequency automatically changes either the burst width in time or the number of cycles per burst, depending on the set Burst Width Mode .

When using modulation  in the *Combine* mode, changing the Frequency setting of Source Signal 1 automatically adjusts the Frequency setting of Source Signal 2. If the Burst Width Mode control for Source 2 is set to **Time**, the relative frequency offset is kept constant, regardless of the Burst Width Mode control setting for Source 1. Whereas, if the Burst Width Mode control settings for Source 1 and 2 are both set to **Cycles**, the frequency offset changes slightly in order to maintain the relative overlap of both signals and their relative cycle difference. In either Burst Width Mode, frequency offset between Source 2 and Source 1 can be arbitrarily set by changing the Frequency setting of Source Signal 2.


When using modulation in the *Hanning* mode, the Frequency setting of the Modulation Signal (Source 2) is always a function of the Carrier Signal (Source 1) *Burst Width* control setting, and is usually not changed independently. However, a manual override of this frequency value is possible.

#### 4.1.2 Burst Width


*Nominal range: 0.1125 to 200  $\mu$ s in 12.5-ns steps, or 1 RF cycle up to the equivalent of a 200  $\mu$ s burst width in 1-cycle steps. For the range of your RAM-5000-SNAP refer to the **Specifications** in the Appendices .*

This control  is for setting the burst width. Depending on the set Burst Width Mode , the burst width may be specified either in terms of a time duration value or in terms of the number of cycles per burst.

##### **Setting the Width in Time Duration**



If the Burst Width is controlled by setting it in time, the corresponding burst cycles value displayed in the numeric indicator immediately below is automatically updated in accordance with the current Burst Frequency .

##### **Setting the Width in Cycles per Burst**

If the Burst Width is controlled by setting the number of RF cycles per burst, the corresponding burst time duration value displayed in the numeric indicator immediately below is automatically updated in accordance with the current Burst Frequency .



**Note:** Although the cycles-per-burst value is shown as a floating point number with one significant digit past the decimal point, changing this value will always round to and reflect the nearest integral RF cycle. The cycles-per-burst control uses a fixed integral step size when changing its value. However, if the cycles-per-burst value is changed indirectly by changing the burst width in time value, the cycles-per-burst value is rounded to the nearest tenth of a cycle to have a more accurate indication of the corresponding number of full cycles per burst. This method of handling the burst cycles value is permissible, since internally it is the burst width value that is used when setting the length of a pulse. The cycles-per-burst is usually a more convenient and intuitive way of specifying a burst length.

### Setting the Width when Modulating


When using modulation  in *Combine* mode, changing the Burst Width setting of Source Signal 1 automatically adjusts the Burst Width setting of Source Signal 2 in order to maintain their relative width difference, which can be arbitrarily set by changing the Burst Width setting of Source Signal 2 either in terms of cycles or time. The Burst Width setting of Source Signal 2 should be sufficiently smaller than that of Source Signal 1 in order to take full advantage of this feature. If you also adjust the Burst Delay  setting of Source Signal 2 you can produce even more signal configurations.

When using modulation in *Hanning* mode, changing the Burst Width setting of the Carrier Signal automatically adjusts the Burst Width setting of the Modulation Signal in order to maintain their relative width difference, which can be arbitrarily set by changing the Burst Width setting of the Modulation Signal either in terms of cycles or time. However, in contrast to the *Combine* mode, the Burst Width *number-of-cycles* setting of the Modulation Signal is never changed as a result of changing the burst width of the Carrier Signal. Instead, the Modulation Signal Frequency settings is adjusted accordingly. That means, similarly to the *Combine* mode, to take full advantage of the relative width tracking feature, the Burst Width *time* setting of the Modulation Signal should be sufficiently smaller than that of the Carrier Signal, and the Burst Delay setting of the Modulation Signal may need to be adjusted as well.

#### 4.1.2.1 Width Mode

Setting this control  determines whether the Burst Width  may be set in terms of *time duration* or in terms of the number of *cycles per burst*.

In addition, the Burst Width *Mode* controls the burst width behavior with respect to frequency changes. That means, the width may be kept constant in terms of the number of cycles per burst or strictly in terms of time duration as the burst frequency is changed.

If "Set Burst Width in:" is set to **Cycles** (Set Burst Width in: ) is selected, the burst width may be set by specifying the number of cycles value. In this mode, if the burst frequency is changed, the burst width will automatically be adjusted in time to maintain the set number of cycles.

If "Set Burst Width in:" is set to **Time** (Set Burst Width in: ) is selected, the burst width

may be set by specifying the time duration value. In this mode, if the burst frequency is changed, the burst width will automatically be adjusted in the number of cycles to maintain the set time duration.

**Note:** Keeping the burst width constant in time, changes the bandwidth of the transmitted burst as the frequency is changed.

### 4.1.3 Burst Delay

Nominal range: 1.6125 to 6550  $\mu$ s in 12.5-ns steps. For the range of your RAM-5000-SNAP refer to the **Specifications** in the Appendices [13-21](#).

This control [3-14](#) is for setting the delay between the trigger and the start of the amplifier gate that creates the high-power pulse.

**Note:** While the maximum possible delay setting is 6550 microseconds, the maximum operating delay will be determined by the settings of the integrator gate delay [5-8](#) and width [5-8](#). The RAM-5000-SNAP User Interface will check the delay setting and automatically reduce the delay so that it will be smaller than the sum of the integrator gate delay and integrator gate width.

When using modulation [4-12](#) in either *Combine* or *Hanning* mode, changing the Burst Delay setting of Source Signal 1 or the Carrier Signal automatically adjusts the Burst Delay setting of Source Signal 2 or the Modulation Signal, respectively, as described below:

- If the Burst Delay setting is stepped up or down (using either the keyboard arrow keys or the small buttons on the user interface control), their relative delay difference is maintained.
- If the Burst Delay setting is changed by directly entering a new value, the relative delay difference is reset to zero, thus making both Burst Delay settings equal.

A certain relative difference between both Burst Delays can be arbitrarily set by changing the Burst Delay setting of Source Signal 2 or the Modulation Signal, respectively.

### 4.1.4 Phase

Nominal range: 0 to 360 deg in 0.022-deg steps (14-bit resolution)

This control [3-14](#) is for setting the start phase of the toneburst.

When enabling Modulation [4-12](#) for the first time (or after having reset the instrument to its default setup), the user interface automatically sets the phase of Source 2, that is, "Source Signal 2" in *Combine* mode and "Modulation Source" in *Hanning* mode, to a value of 180 degrees and 270 degrees, respectively. A manual override of this phase setting is possible.

When using modulation in the *Combine* mode, changing the Phase setting of Source Signal

1 automatically adjusts the Phase setting of Source Signal 2 in order to maintain their relative phase difference, which can be arbitrarily set by changing the Phase setting of Source Signal 2.

### 4.1.5 Amplitude

*Nominal range: 0 to 100%-FS in 0.024% steps (12-bit resolution)*

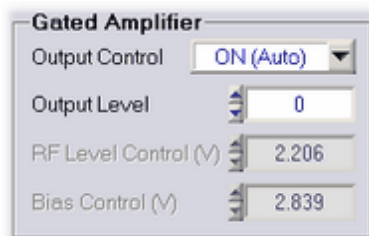
*Advanced Edition only*

This control  is for setting the output amplitude level of the synthesizer.

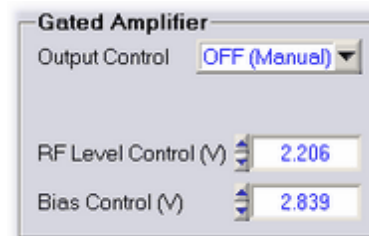
The synthesizer output level control provides an auxiliary method for setting the burst amplitude, which is done at the low-level stage of the signal source. The values always represent a percentage of the full scale (%-FS), where the maximum or full scale is determined by the present gated amplifier settings. Due to hardware limitations, the possible level values cover a wide range of "odd" numbers, as they are purposefully not rounded to a lower precision.

This parameter is usually left at its maximum value to achieve optimum gated amplifier power output. However, in certain experimental cases, this control may provide a more convenient way to adjust the overall power output of the gated amplifier by reducing the synthesizer output level.

## 4.2 Gated Amplifier







*The Gated Amplifier controls in Automatic Output Control mode.*



*The Gated Amplifier controls in Manual Output Control mode.*

Each Gated Amplifier of the RAM-5000-SNAP Pulse Source setup has the following control options:

- Output Control 
- Output Level 
- RF Level Control 
- Bias Control 

## 4.2.1 Output Control

Standard settings: Manual, Auto, and Auto-Fine

This control  $\overline{3-14}$  is for setting the gated amplifier output control mode.

The gated amplifier output level is controlled by the RF Level Control  $\overline{4-8}$  and the Bias Control  $\overline{4-9}$  settings. Because these settings are dependent on both the frequency and the desired output level of the high power RF pulse, an algorithm has been incorporated into the RAM-5000-SNAP software to set both the RF Level Control and the Bias Control to optimized (see note below) settings.

**Note:** Please note that the default RF Level and Bias settings have been optimized based upon a 50 Ohm resistive load. In certain situations, which can occur with unmatched loads, it may be useful to manually adjust the RF Level and Bias settings to optimize the signal quality.

The following output control settings are available:

**Manual** disables the use of any output control algorithm. In this mode, you must manually set the RF Level Control and the Bias Control voltages to achieve a desired gated amplifier output level and burst shape characteristics.

**Auto** enables the use of the standard output control algorithm. In this mode, you set the gated amplifier output level using the Output Level  $\overline{4-8}$  control over an arbitrary range 0 to 100 with a step size of "1".

**Auto-Fine** enables the use of the standard output control algorithm with increased dynamic range and a smaller step size. In this mode, you set the gated amplifier output level using the Output Level  $\overline{4-8}$  control over the range -25 to 100 with a step size of "0.33". Please note however, the level range -25 to 0 produces an output characteristic that is not as optimized as the range 0 to 100 with respect to frequency changes.

**Note:** When setting the Output Control to either **Auto** or **Auto-Fine**, and the current Output Control is set to **Manual**, an algorithm automatically searches for the closest Output Level match based on the current RF Level Control voltage. The thus found Output Level is used to initialize both the RF Level and Bias Control settings based on the standard Output Control algorithm and the present frequency. That means, while the automatically set RF Level Control voltage may be very close to the value you previously set manually, the Bias Control voltage however might be automatically adjusted to a very different value because it is subject to the Output Control algorithm.



## 4.2.2 Output Level

Nominal range: 0 to 100

This control  $\overline{3-14}$  is for setting the high-power output level of the respective gated amplifier using the default output algorithm.

If the Output Control  $\overline{4-7}$  mode is set to any other setting than Manual, the numeric output level control is enabled for user input. Depending on the selected output control mode, the output level setting is used in the particular optimization algorithm to set the output level of the high-power RF pulse. A setting of 100 corresponds to a pulse amplitude of 1440 Vpp, and a setting of 10 corresponds to 144 Vpp, if measured into a 50 Ohm load. Because the gain characteristics of each gated amplifier can vary, these settings are approximate and the user is directed to the calibration data located at the end of the RAM-5000-SNAP hardware manual to determine the appropriate setting for their gated amplifier. For frequencies above 10 MHz, the algorithm uses the 10 MHz values.

If the input impedance of the transducer is high, or if the RF receiver is set at its lowest gain setting and is still saturated by the strength of the received signal, it may be necessary to reduce the gated amplifier output. This can be accomplished by reducing the output level control setting, or if necessary by reducing the RF Level Control  $\overline{4-8}$  voltage when in manual output control mode.

## 4.2.3 RF Level Control

Nominal range: 0 to 4.999 V in 0.001-V steps (12-bit resolution)

This control  $\overline{3-14}$  is for setting the RF level control voltage of the respective gated amplifier.

The RF level control is used to set the amplitude of the RF signal in the first "low-level" stage of the gated amplifier. Typically, this control determines the output level of the high power RF burst. Because the overall gain of the gated amplifier is frequency dependent, the RF level control voltage setting will need to increase as the frequency is increased to maintain a constant output level. The calibration data at the end of the RAM-5000-SNAP hardware manual will be of assistance in choosing this value.

**Note:** The RF level control voltage will be set automatically as long as the Output Control  $\overline{4-7}$  mode is not set to **Manual**.

If the receiver is saturated by the strength of the received signal even at 22 dB, its lowest possible gain setting, it may be necessary to reduce the RF level control voltage setting. However, the preferred method of reducing the signal is to place a high power stepped attenuator between the "High Power RF Pulse Out" and the transducer.

**CAUTION !!!** *If the gated amplifier output is reduced via significantly lowering the output control levels, the spurious signals at the leading and trailing edges of the burst may be more important driving sources than the burst itself. An external high power attenuator will solve this problem.*

#### 4.2.4 Bias Control


*Nominal range: 0 to 4.999 V in 0.001-V steps (12-bit resolution)*

This control  is for setting the bias control voltage of the respective gated amplifier.

The bias control is used to set the bias current in the transistors (MOSFET's) in the power output stage. At low settings of the bias current, the RF signal can switch the transistors on and off as the RF voltage crossed the threshold voltage for each transistor and this switching appears as distortion in the high power RF pulse. This distortion introduces a component at the second harmonic into the output pulse. Increasing the bias current in the transistor will prevent the transistor from turning on and off at the zero crossing of the RF and reduce the second harmonic distortion in the RF pulse. However, increasing the bias current increases the temperature in the power output stage and decreases the overall duty cycle. Typically the distortion is most evident at frequencies above 1 MHz. If the RAM-5000-SNAP system is being used with resonant transducers that do not respond at frequencies other than the fundamental frequency for frequencies below 1 MHz, the bias control may be decreased for operation at a higher duty cycle (up to the maximum).

**Note:** The gain in the final output stage is sensitive to the bias current, so the RF output level will change as the setting of the bias control is changed.

Because the overall gain of the gated amplifier is frequency dependent, the bias control voltage setting will need to increase as the frequency is increased to maintain a constant output level. The calibration data at the end of the RAM-5000-SNAP hardware manual will be of assistance in choosing this value.

**Note:** The bias control voltage will be set automatically as long as the Output Control  mode is not set to **Manual**.

Increasing bias control voltage will increase the high voltage current used in the power output stage and will decrease the available duty cycle. Decreasing the bias control will increase the amount of distortion in the high power RF pulse as discussed above. However, in some circumstances, it may be desirable to allow more distortion in the output pulse for the ability to operate at a higher duty cycle (up to the maximum).

### 4.3 Output Enable



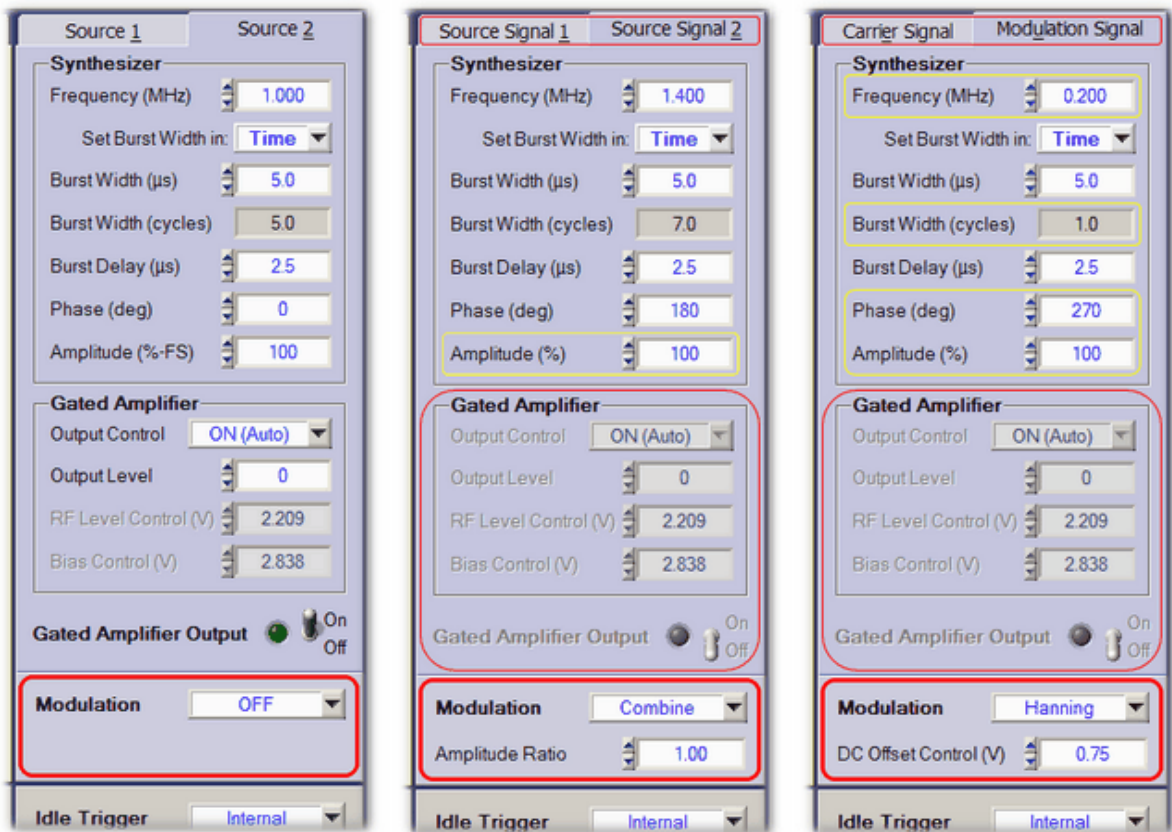
*Output Enable Control*

This toggle switch allows the specific gated amplifier to be made active or inactive in response to a trigger. In effect, this function disables or enables the output of the Pulse Source.

**Note:** Please note that this control has no effect on the high-voltage of a gated amplifier. The high-voltage can only be turned *on* or *off* from the RAM-5000-SNAP hardware front panel using the toggle switch, labeled HIGH VOLTAGE, which is located below the red LED.

**Note:** If the pulse amplitude is approximately 100 Volts peak-to-peak or higher into 50 Ohm (Output Level <sup>4-8</sup> setting of about 5), the green indicator lights on the RAM-5000-SNAP hardware front panel, located just over the RF burst high-power output BNC connectors, are useful to determine which gated amplifier is active at any given time when triggered.

### 4.4 Modulator







The Pulse Source controls when Modulation is off.

The Pulse Source controls when using Modulation mode Combine.

The Pulse Source controls when using Modulation mode Hanning.


The Modulation controls, in conjunction with the controls for either Synthesizer <sup>4-2</sup>, are for setting up Pulse Source Modulation. When Modulation is enabled, the synthesizer no.1 signal, that is sent to gated amplifier no.1, is first modulated in the Modulation module by the signal produced in synthesizer no. 2. That means, gated amplifier no.2 (if present with your

particular RAM-5000 instrument configuration) is completely bypassed in terms of signal routing in the hardware, and is therefore disabled in the RAM-5000-SNAP User Interface. Also, the user interface tabs labeled "Source 1" and "Source 2" change to "Source Signal 1" and "Source Signal 2", respectively, when using additive modulation, and change to "Carrier Signal" and "Modulation Signal", respectively, when multiplicative modulation is enabled. The following additional controls are available with the Modulator:

- Modulation Type  4-12
- Modulation Amplitudes  4-23
- Ratio of Amplitudes  4-23
- Modulation Signal DC Offset  4-24

#### 4.4.1 Modulation Type

Standard settings: OFF, Combine, and Hanning

This control  is for enabling source signal modulation and for setting the type of modulation. **Combine** is equivalent to *additive* modulation, and **Hanning** is a special case of *multiplicative* modulation. Each setting is described below.

##### **Modulation OFF**

If modulation is set to **OFF**, the output signal from the Synthesizer of Source 1 will not be modulated before it is sent to Gated Amplifier No.1, where it will be gated and amplified into a high-power RF burst. The output signal from the Gated Amplifier will have sharp corners at the start and end of the RF burst. These sharp corners will result in the generation of harmonic frequencies, commonly called sidebands. By modulating the Synthesizer output before it is sent to the Gated Amplifier it is possible to reduce these sidebands and reduce the harmonic content of the RF burst. An example of the RF output with modulation set to **OFF** is shown in Figure 4-1. The frequency of the carrier wave is 3 MHz and the burst width is 9 microseconds.

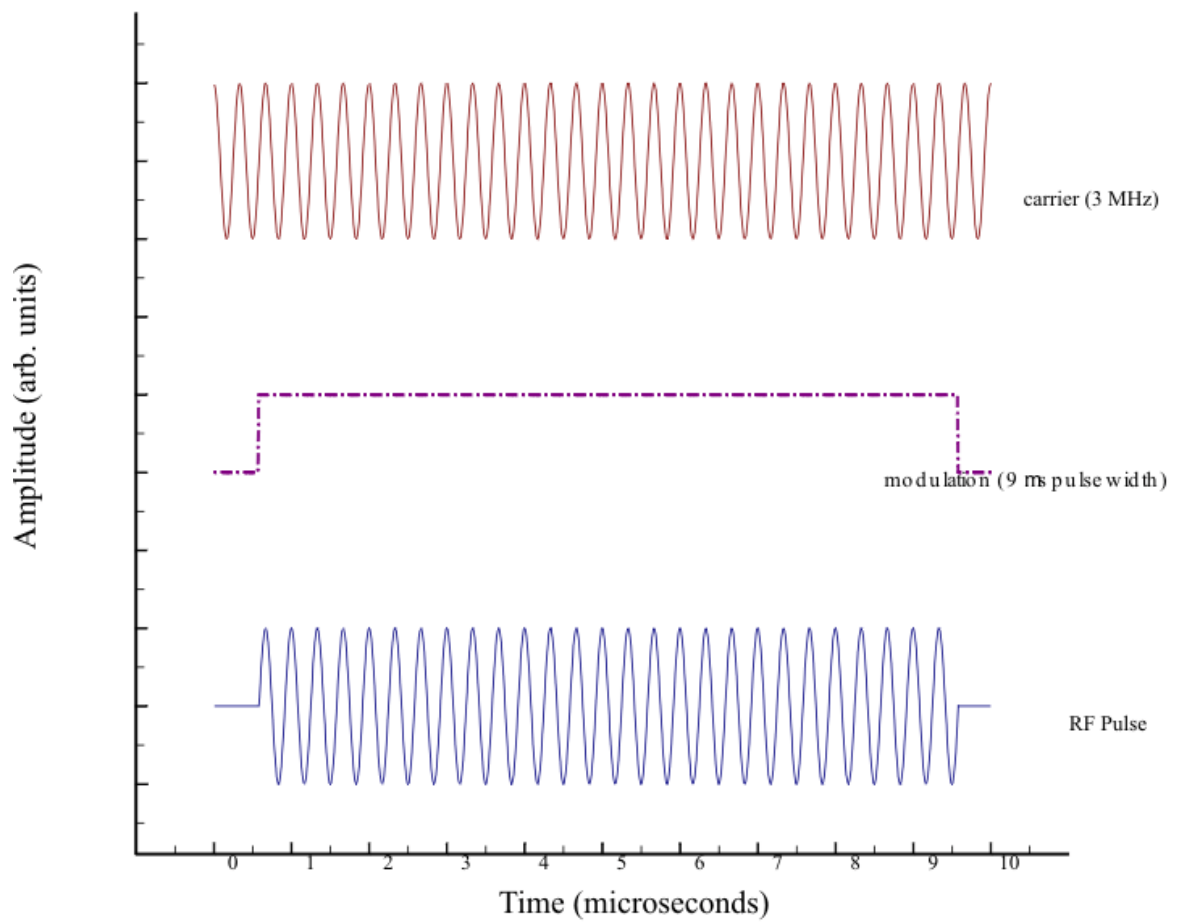


Figure 4-1. RF Pulse with Square Modulation.

To reduce the amplitudes of the frequency sidebands, two different modulation methods have been incorporated into the RAM-5000-SNAP system, which are described in the following.

## Combine

If the frequency settings of Source 1 and Source 2 are close, it is possible to drive a single transducer simultaneously with two different frequencies and then detect the difference frequency. This type of modulation can be selected by selecting **Combine**. For example, this type of modulation allows an experimenter to drive one transducer with 3 MHz and 3.1 MHz and detect with a second transducer at 0.1 MHz, (the difference frequency.) The output waveform with the above frequencies, as shown in Figure 4-2, will be modulated at a frequency of  $(\omega_1 - \omega_2)/2$  or 0.05 MHz, for the example shown above. The carrier frequency will be  $(\omega_1 + \omega_2)/2$  or 3.05 MHz for the example shown above. The resulting waveform will be a series of beats. By setting the burst width to be 10 microseconds (half the period of 0.05 MHz) one “beat” can be fed to the gated amplifier for amplification. Please note however, because the slope at the turn-on and turn-off are set by the modulation frequency, there is still some high frequency component introduced at the beginning and end of the pulse.

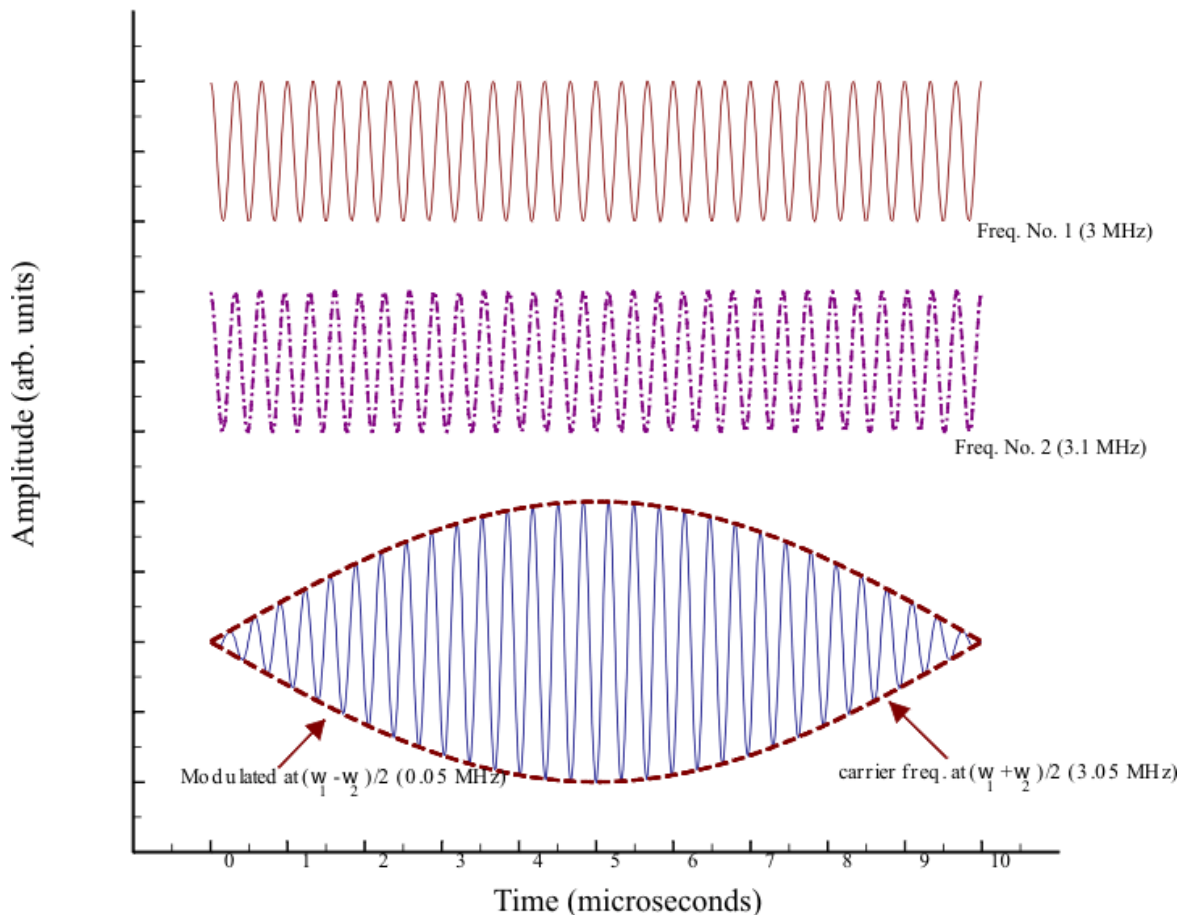


Figure 4-2. Combination of Two RF Frequencies.

For information on how to control the various signal source parameters when using **Combine** modulation, please see the topic Modulation Combine in Operation [4-17](#).

## Hanning

With modulation set to **Hanning**, the output signal from the Synthesizer of Source 1, operating at Frequency 1, is multiplied by the output signal from the Synthesizer of Source 2, which operates at Frequency 2. Frequency 1 represents the carrier frequency and Frequency 2 the modulation frequency. Normally this will result in a waveform similar to that shown in Figure 4-2 above. However by introducing a DC offset to the modulation before the multiplication, the modulation can be given by:

$$m(t) = \begin{cases} 0.5 - 0.5 \cos(2\pi f_m t), & 0 \leq t \leq T \\ 0, & \text{otherwise} \end{cases} \quad (4-1)$$

where  $f_m$  is the modulation frequency and 0 to  $T$  is the time interval of interest, (i.e. the burst width). This type of modulation is known as a *Hanning window*. With this type of modulation the slope of the modulation at the turn-on and turn-off would be zero.

An example is shown in Figure 4-3, where the carrier frequency is 3 MHz and the modulation frequency is 0.1 MHz (for a burst width of 10 microseconds).



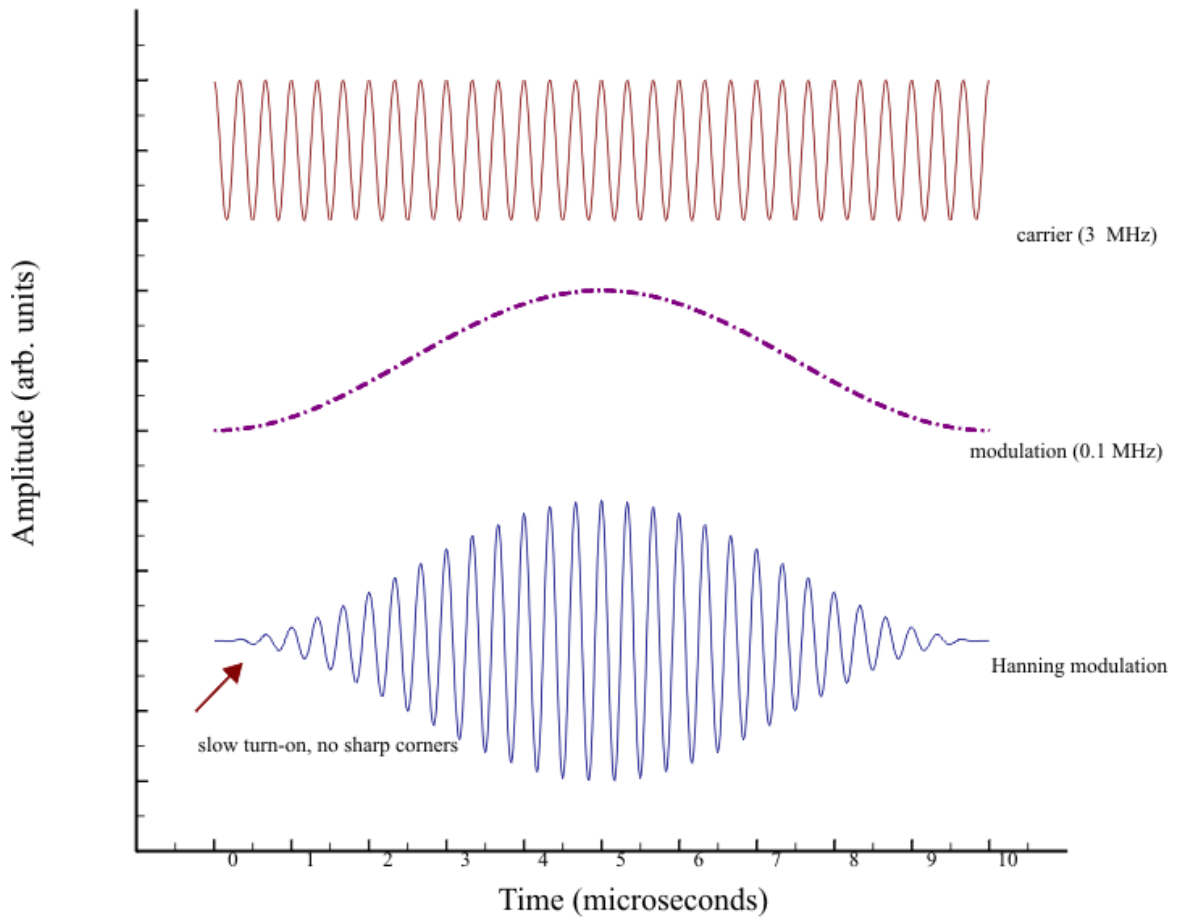



Figure 4-3. Hanning Modulation.

For information on how to control the various signal source parameters when using **Hanning** modulation, please see the topic [Modulation Hanning in Operation](#) <sup>4-18</sup>.



To examine the RF modulation before it is sent to Gated Amplifier No.1, a monitor point "GA No.1 Modulation Monitor" has been provided on the rear panel. The RF level is  $-40$  dB below the 1 V peak-to-peak output which is sent to the Gated Amplifier, if the monitor is terminated in a 50 Ohm load. Please note: Both synthesizers are gated on and off. The length of the RF signal observed at the modulation monitor (or alternatively the length the synthesizers are operating) will depend of the relative settings of the burst width and delays for Gated Amplifier No.1 and No.2. Both synthesizers are turned off together 2 microseconds after the end of the widest amplifier gate. For example, if the delays for both gated amplifiers are 0.1 microseconds and the burst width for GA No.1 is 10 microseconds, and GA No.2 is 20 microseconds, both synthesizers will be turned off 22.1 microseconds after the trigger. This delay in turning off the synthesizers does not affect the high-power RF burst, since additional gating is provided in the first "low-level" stage of the gated amplifier. However, the "GA No.1 Modulation Monitor" examines the RF level before the additional gating so any modulated RF

signal will be slightly longer than the high power RF burst.

#### 4.4.1.1 Combine Operation

When operating the RAM-5000-SNAP in the Combine modulation mode, various control settings of the Synthesizer  for Source Signal 2 track the settings of the Synthesizer for Source Signal 1, in order to maintain a certain modulation characteristic.

The RAM-5000-SNAP User Interface defines a number of default settings for the Modulator and the Synthesizer of Source Signal 2, and to a lesser extent for the Synthesizer of Source Signal 1.


You can invoke the default settings for Combine modulation at any time via the Modulation  control's context menu (mouse right-click), by selecting the item **Reset Source Signal 2 settings to default**. In addition, when you set the Modulation control to *Combine*, that is, when you start modulating in this mode, a Modulation control dialog  may appear with options for how to pre-configure Source Signal 2, one of the available options always being **Apply default settings** or **Reset to default settings**.

When default settings are applied the following signal parameters are set automatically for the respective source (all other parameters remain unchanged):

Source 1: Amplitude = 100%

Source 2: Frequency = Frequency + 2 / Burst Width of Source Signal 1  
Phase = 180 degrees + Phase of Source Signal 1  
Burst Delay and Width = Delay and Width of Source Signal 1  
Amplitude = 100%.

These settings produce 2 beats at maximum modulation amplitude, which may then be adjusted to suit the particular signal modulation need.

For example, the number of beats may be adjusted by first setting the Burst Width Mode  control for Source 1 to **Time**, and then by changing the Burst Width of Source Signal 1 until the desired number of beats are either added or removed. This is so because the Burst Width of Source Signal 2 is automatically changed to maintain the relative overlap of the two signals, while keeping the Frequency of Source Signal 2 fixed. However, when the Burst Width of Source Signal 1 is adjusted with the Burst Width Mode control set to **Cycles**, the outcome will be slightly different. To maintain the relative overlap of both signals, but also their relative cycle difference, the Frequency of Source Signal 2 must be adjusted. As a result, the beat count stays constant.

**Note:** To adjust the number of beats without changing the overall burst width, simply set the Burst Width Mode control for Source 2 to **Cycles** and adjust the relative cycle difference as needed.

When changing the Frequency setting of Source Signal 1, the Burst Width Mode control settings for Source 1 and 2 also play a significant role in how the Frequency setting of Source Signal 2 is automatically adjusted. That is, for either Burst Width Mode control setting for

Source 1, when the Burst Width Mode control for Source 2 is set to **Time**, the relative frequency offset is kept constant. However, when the Burst Width Mode control settings for Source 1 and 2 are both set to **Cycles**, the frequency difference changes slightly in order to maintain the relative overlap of both signals and their relative cycle difference.

In general, adjusting any of the Source Signal 1 (synthesizer) parameters automatically adjusts the relevant signal parameter of Source 2. That is, when the Frequency, Burst Width/Delay time, or Phase of Source Signal 1 is changed, the same parameter is also changed for Source 2, while maintaining each particular offset, such as the difference frequency or the difference in phase (nominally 180 degrees). However, changing any of these signal parameters for Source 2 leaves the corresponding Source 1 parameter unchanged. The Amplitude parameter may be adjusted for either signal source without affecting the other, depending on the ratio lock setting (see Modulation Amplitude Ratio [4-23](#)). This combination of signal parameter adjustment possibilities allows for designing a wide range of additive signal modulation scenarios and then control the compound modulated burst signal in the same way as one would control a normal tone burst when Modulation is OFF.

When scanning [6-8](#) either one of these signal parameters, the same functionality applies as for the interactive parameter control using the Source 1 and 2 tabs (panels). That is, if the Frequency of Source Signal 1 is scanned, the Frequency of Source Signal 2 is automatically scanned as well to maintain the difference frequency or a certain ratio. However, scanning the Frequency of Source Signal 2 will not change the Frequency setting of Source 1. In the case of a Frequency Scan [6-9](#), a second X axis is shown at the top of the Scan Graph [7-15](#) when scanning Source Signal 1. The frequency labels on the top X axis may appear in the color red when the difference frequency setting in conjunction with the primary frequency scan range would force certain secondary signal frequencies out of the range of operation. If this occurs, a scan can not be initiated until the various settings have been corrected, which will be indicated by black frequency labels on the top X axis of the Scan Graph.

#### 4.4.1.2 Hanning Operation

When operating the RAM-5000-SNAP in the Hanning modulation mode, various control settings of the Synthesizer [4-2](#) for the Modulation Signal track particularly related settings of the Synthesizer for the Carrier Signal, in order to maintain a certain modulation characteristic.

As noted in section 4.4.1 Modulation [4-15](#) for the case of Hanning, the frequency of the Modulation Signal should be set to the reciprocal of the desired burst width of the Carrier Signal. Therefore, the modulation frequency will be set automatically by the RAM-5000-SNAP User Interface and is updated when the burst width of the Carrier Signal changes.

Thus, the RAM-5000-SNAP User Interface defines a number of default settings for the Modulator and the Synthesizer of the Modulation Signal, as well as to some degree for the Synthesizer of the Carrier Signal.

You can invoke the default settings for Hanning modulation at any time via the Modulation [4-12](#) control's context menu (mouse right-click), by selecting the item **Reset Modulation Signal settings to default**. In addition, when you set the Modulation control to *Hanning*, that is, when you start modulating in this mode, a Modulation control dialog [4-19](#) may appear with options for how to pre-configure the Modulation Signal, one of the available options always

being **Apply default settings** or **Reset to default settings**.

When default settings are applied the following signal parameters are set automatically for the respective source (all other parameters remain unchanged):

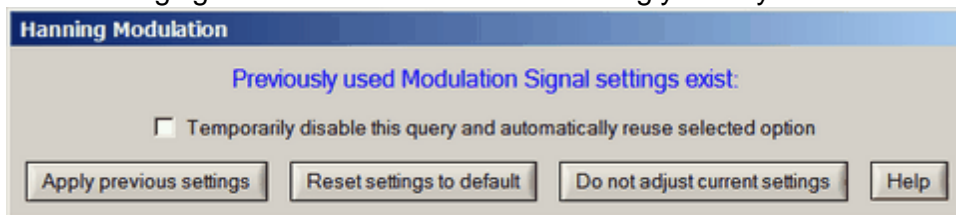
- Source 1: Phase = 0 degrees
- Source 2: Frequency = 1 / Burst Width of Carrier Signal (Source 1)  
 Phase = 270 degrees  
 Burst Delay and Width = Delay and Width of Carrier Signal  
 Amplitude = 100%  
 DC Offset = 0.75 V or 100% if calibrated <sup>4-25</sup>

These settings may subsequently be adjusted to suit the particular signal modulation need. For example, the Frequency, Phase, and Amplitude of the Modulation Signal (Source 2) may be adjusted in conjunction with the DC Offset to produce a variety of other modulation shapes/envelopes for the Carrier Signal (Source 1) burst.

Adjusting the Burst Width of the Carrier Signal with the Burst Width Mode <sup>4-4</sup> control set to either **Cycles** or **Time** will automatically adjust the Frequency and Burst Width of the Modulation Signal to maintain the Modulation Signal *cycle* setting, typically one full RF cycle. When adjusting the Burst Delay time of the Carrier Signal, the Delay time of the Modulation Signal is adjusted as well to maintain a constant delay offset, which may be zero. However, changing the Burst Width and Delay of the Modulation Signal will not affect the corresponding parameter of the Carrier Signal.

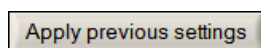
### 4.4.1.3 Modulation Dialog

When changing the Modulation <sup>4-12</sup> control setting you may see this



1. *The Modulation control dialog when switching to Hanning a second time, and both the previously used and the currently active Source 2 settings have been successfully validated for use with Hanning modulation.*

or a similarly looking dialog popping up before the selected modulation setting is fully activated. The selected modulation is shown in the title bar of the dialog box. The dialog will be populated with a variable number of buttons, each implementing a different action for how to set up the signal generator of the modulation source, or allowing you cancel the selected modulation. There is also the option <sup>4-2</sup> to prevent this dialog from showing when you frequently use the same type of modulation signal settings.



...uses settings that were used before with the selected modulation. That means, these settings were used when the selected modulation was already active at some time earlier

since launching the RAM-5000-SNAP User Interface.

Please note, at the present time these settings do not transfer between UI restarts. To reuse settings during another UI session, please create a setup file when you have highly customized signal modulation settings and reload them later as needed.

Reset settings to default

...uses settings that always put the modulation signal source into a well-defined state.

If you selected *Combine* as the modulation type, the synthesizer of Source 2 is automatically programmed to produce a secondary toneburst signal, that is very similar to the toneburst signal of Source 1. The pulse parameters of the secondary toneburst signal are dynamically defined based on the pulse parameters of the primary toneburst signal and are chosen to optimize their addition with a relatively smooth start and end of the combined burst signal, by choosing a certain pre-defined <sup>4-17</sup> secondary frequency and phase configuration.

Similarly, if you selected *Hanning* modulation, the synthesizer of Source 2 is pre-programmed to always produce a Hanning window <sup>4-19</sup> for the entire toneburst signal of Source 1.

And, if you selected the Modulation control setting *OFF*, the synthesizer settings of Source 2 are reset to default parameters for your RAM-5000-SNAP system hardware configuration.

Do not adjust current settings

...leaves the settings unchanged.

This option is useful, for example, when you want to inspect the individual signal components before enabling modulation, or afterwards with signal modulation now disabled.

Apply default settings

...is similar to "Reset settings to default", but is usually only shown early on when there are no previous settings available for the selected modulation.

Cancel

...allows you to cancel the selected Modulation control setting and revert back to the prior setting. This option, though rare, is shown when the option "Do not adjust current settings" would normally be shown, however the "Do not adjust current settings" action could not be validated for using with the selected type of modulation, when taking into account other instrument configuration criteria.

To cancel a new Modulation control setting may be useful when you are definitely interested in using the current

modulation source settings with the selected modulation type, but if that can not be realized due to hardware limitations or other operational instrument settings, and the only other alternative(s) to close the dialog is to use other settings that you may not be interested in, thereby changing your current (possibly very precious) settings.

Temporarily disable this query and automatically reuse selected option

Enabling this option causes the dialog to not show for the next 15 minutes when changing the modulation type, and instead automatically use the action that was selected last.

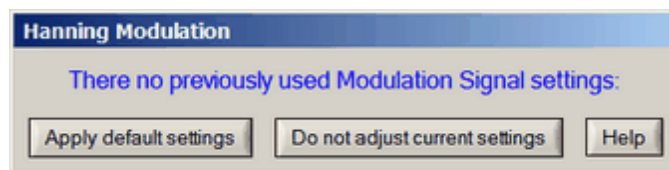
The RAM-5000-SNAP User Interface still verifies the validity of the selected action prior to committing to a new modulation type. If the selected action is found to be invalid for a particular switch, or because other instrument operation settings meanwhile have changed to invalidate this, the dialog is shown regardless of the timer state. Another way to bring back the dialog is to select the item **Re-enable modulation signal settings query** from the context menu (right-clicked) of the Modulation control.

To temporarily disable the dialog is useful for when you switch back and forth frequently, while you investigate the effect of using two different types of modulation settings.

### ***Why do I not see a particular action button on the dialog, and at other times I do?***

#### ***Selecting a different Modulation control setting for the first time***

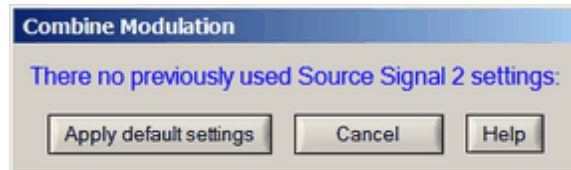
When you select a different Modulation control setting for the first time, that is, since launching the RAM-5000-SNAP User Interface, there are no previous modulation settings other than the currently active ones. That means, there are basically only two options available. The first option is to "Apply default settings" to the setup of the modulation signal source. The second option can only be to simply not change the setup of the modulation signal source. This option would allow you to investigate their effect on the primary toneburst signal if enabling modulation, or to investigate the modulation signal itself via the output of gated amplifier no.2 (if installed) upon disabling modulation. The corresponding dialog that is produced for this case is shown below in screen shot 2.



*2. The Modulation control dialog when switching to a different type of modulation for the first time.*

On rare occasions, however, the second option is not really an option and is actually unavailable. For example, that may be the case if your particular RAM-5000-SNAP system would have two gated amplifiers, and both with sufficiently different frequency characteristics.

Thus, if you are using a toneburst via gated amplifier no.2, and the frequency of that toneburst were to fall outside of the operating range of the primary gated amplifier when modulating you might run into the situation that the action button for "Do not adjust current settings" is replaced by the option to "Cancel" the selected Modulation control setting. The corresponding dialog that is produced for this case is shown below in screen shot 3.



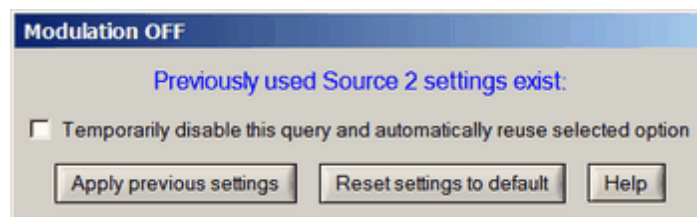
*3. The Modulation control dialog when switching to Combine modulation for the first time, but the current Source 2 settings would not be valid for using through Source 1.*

**Note:** The check box option to "Temporarily disable this query and automatically reuse selected option" is also not shown until you have been using the same Modulation control setting at least twice.

### **Selecting the same Modulation control setting a second time**

When you select a different Modulation control setting that has been used before (i.e., since launching the RAM-5000-SNAP User Interface) there are now up to three options for how to initialize the signal generator of the modulation source. This is the most common scenario when you work with different types of modulation and experiment frequently with all the available control settings. The dialog that reflects this is shown in screen shot 1<sup>[4-19]</sup> at the beginning of this help topic.

However, when you are disabling Hanning modulation, you will usually see the dialog missing the "Do not adjust current settings" button. This is so because the typical Hanning modulation signal frequency hardly ever will pass through any of RITEC's standard gated amplifiers. Hence, there would no point in leaving the Hanning modulation signal settings unchanged when selecting Modulation *OFF*. The dialog that is produced for this case is shown below in screen shot 4.



*4. The Modulation control dialog when the current Source 2 settings are not valid for use with the selected type of modulation.*

***Why do I sometimes not see any dialog at all when changing the Modulation setting?***

This can occur when there is only one possible action, that the RAM-5000-SNAP User Interface determined to be feasible, just prior to when the dialog would normally be shown. When this situation arises the only possible action is taken automatically without prompting you to confirm. Usually, this implies that either the action "Apply default settings" or the action "Reset settings to default [4-20]" was invoked. However, if your RAM-5000-SNAP has only a single gated amplifier installed and you are switching modulation to the OFF position, you will not see a dialog either as the action "Do not adjust current settings" is simply used.

#### 4.4.2 Amplitude Control

*Nominal range: 0 to 100% in 0.024% steps (12-bit resolution)*

This control [3-14] is for setting the relative amplitude of the RF signal from either source in the Modulator. Either control is only available when Modulation [4-12] is set to **Combine**, and replaces the respective synthesizer Amplitude [4-6] control.

When Modulation is set to **Hanning**, the synthesizer Amplitude control is made available to allow for adjusting the amplitude of the Modulation Signal (otherwise Source 2).

When the Amplitude Ratio [4-23] is **locked**, a change in the amplitude of the RF signal from either source automatically changes the respective amplitude setting of the other signal source in accordance with the current amplitude ratio setting.

**Note:** The relative amplitudes of both RF signals may also be controlled via the Amplitude Ratio [4-23] control.

#### 4.4.3 Ratio of Amplitudes

This control [3-14] is for setting the relative amplitude of the RF signal from either source via the ratio between the respective amplitude settings for both sources. The ratio control is only available when Modulation [4-12] is set to **Combine**.

If the ratio is set to 1.0, the RF level control voltages for the signal from either source are set to the same value in the Modulator. If the ratio is set to a value less than 1.0, the amplitude of Source Signal 2 is adjusted and set to the corresponding fraction of the amplitude of Source Signal 1, that is, Signal 2 will have a smaller amplitude than Signal 1. If the ratio is set to a value greater than 1.0, the amplitude of the Source Signal 1 is adjusted such that the amplitude of Source Signal 2 will be larger by the corresponding multiple.

**Note:** To adjust the amplitude setting for the RF signal from either source directly use the Modulation Amplitude [4-23] control.

The amplitude ratio may be **locked** or **unlocked**. If it is locked, a change in the relative modulation amplitude of the RF signal from either source automatically changes the respective amplitude setting of the other signal source in accordance with the current amplitude ratio setting. To lock or unlock the ratio, right-click the mouse pointer over the control and select **Lock/Unlock** from the context menu.



#### 4.4.4 DC Offset Control

Nominal range: -2.5 to +2.5 V in 0.001-V steps (12-bit resolution)

This control [3-14](#) is for adjusting the DC offset of the modulation signal. The DC offset control is only available when Modulation [4-12](#) is set to **Hanning**.

The output of Synthesizers No.1 and No.2 has been set so that the amplitude,  $A$ , is 1 V peak-to-peak at 1 MHz. This amplitude will decrease slightly as the frequency is increased to 30 MHz. Typically, the DC offset control voltage will be set to approximately 1 V or the equivalent of the "0.5" in Equation 4-1 [4-15](#) shown above.

By changing the offset control voltage, it is possible to adjust the DC offset of the modulation signal so that the RF burst starts and ends smoothly or exhibits some other desired signal characteristic.

In the RAM-5000-SNAP User Interface, the offset control setting of 0.75 V is the default, but which may require some fine-tuning. This value may also be changed to design other window shapes, when modified in conjunction with the Frequency [4-3](#) and/or Phase [4-5](#) of Source 2 ("Modulation Signal").

Because the optimum DC offset control voltage that produces a clean Hanning modulation may vary between different RAM-5000 instruments, a calibration procedure has been incorporated into the RAM-5000-SNAP User Interface. Thus, you can choose to calibrate the DC offset control from the Tools [3-7](#) menu, or by selecting the item **Calibration...** [4-25](#) from the control's context menu, and then follow the instructions.

Calibrated nominal range: -100% to +100% in 0.1-% steps

**Note:** Typically, the usable DC offset control range extends from well below -100% and to well above +100%, sometimes as much as -225% to +225%, which depends on the particular Modulator module in your system.

In the calibrated DC offset control mode, a clean Hanning modulation results for a Modulation Signal phase setting of 270° at a DC offset setting of +100%, and similarly for a phase setting of 90° at a DC offset setting of -100%, when the Modulation Signal amplitude setting is at 100% (i.e., maximum).

When resetting [4-18](#), the calibrated offset control defaults to a value of 100%.

When using the calibrated DC offset control mode, you can switch to the conventional control mode by right-clicking over the offset control and then selecting the item **Change control values into D/A Ctrl-Volts** from the displayed context menu. This may be useful, for example, if you want to compare against the instrument settings used for previously acquiring data without DC offset control calibration.

And, provided your RAM-5000-SNAP has been calibrated before, when using the




conventional DC offset control mode (i.e., in Volt), you can switch back to the calibrated control mode by selecting the item **Change control values into calibrated Percent** from the offset control's context menu.

#### 4.4.4.1 Calibration



The RAM-5000-SNAP User Interface includes a calibration procedure that can accurately determine and appropriately scale the DC offset control voltages that produce well defined Modulation Signal offsets. Once the DC Offset control has been calibrated, the control values will no longer be referencing the DC offset D/A control voltages directly but rather in terms of percent of the maximum Modulation Signal amplitude.

Because your RAM-5000 instrument is capable of analyzing waveform signals, the preferred calibration procedure is fully automated.

##### ***Preparing for the calibration:***

1. Make sure your instrument has sufficiently warmed up, that is, that it has been running for at least 30 minutes.
2. Connect a high-power 50 Ohm load (such as the RITEC RT-50) or a fully engaged high-power attenuator (such as the RITEC RA-32 or similar) to the **RF BURST NO.1 HIGH POWER OUT**  connector.
3. Using a short BNC cable, connect the **RECEIVER NO.2 IN**  port directly to the **RF BURST NO.1 MONITOR**  port.
4. Turn on the **HIGH VOLTAGE** using the switch on the instrument front panel.

##### ***Launching the calibration:***

You can do this either from the Tools  menu or by selecting the item **Calibration...** from the DC Offset control's context menu when the Modulation  control is set to *Hanning*.

##### ***The calibration:***

Upon starting, the currently active instrument settings are saved so they can be restored.

After that, the RAM-5000-SNAP User Interface automatically restarts into the calibration mode using a special set of instrument settings.

The DC Offset control is then being calibrated by acquiring various data as a function of

different Modulation Signal phase settings and a range of DC offset D/A control voltages, while looking for certain features in the analyzed waveform signal.

During this process, a progress dialog will provide you with a status update and the opportunity to cancel at any time. The entire calibration process only takes about a minute, usually even less than that. If you choose to cancel, the RAM-5000-SNAP User Interface immediately restarts and fully restores the state it was in just before the calibration started.

When all necessary data have been collected by this process the new control range will be built and stored, which is now based on percent relative to the Modulation Signal amplitude at maximum control setting.


At the end, the RAM-5000-SNAP User Interface automatically restarts and fully restores the state it was in just before the calibration, with the exception of the DC Offset control.

If the calibration procedure completed successfully, the DC Offset control will automatically use a range of control values that spans nominally from -100% to +100%, at a resolution of 0.1%. Dependent upon the particular Modulator module that is in your RAM-5000 system, the actual range however will extend from well below -200% up to well above +200%, most of the time.

However, if the calibration procedure did not complete successfully, the DC Offset control will use the conventional control range which is based on D/A control voltage values. The calibration algorithm regards the outcome to be a failure if it can not determine the results of various calculations with an error that is below a certain threshold.

### ***After the calibration:***

Immediately after a calibration, the active DC Offset control setting will be a value that is based on your previous setting but also the newly determined calibration data, if successfully obtained. Hence, while the control setting might show a different value, the internal D/A control voltage is initially still the same, until you adjust the control value.

You can quickly verify the qualitative outcome of a calibration, or the current state of it at any time later, by setting the Modulation Signal Phase control to 90° and the DC Offset control to -100%. A clean Hanning modulation of the carrier wave burst should be the result. Likewise, you should see a very similarly looking modulation result at a Modulation Signal phase setting of 270° and a DC offset setting of +100%, which the respective controls always default to when reset .

**Note 1:** Verifying the state of the existing DC Offset control calibration data, in the manner described just above, always assumes that the Modulation Signal Amplitude control is set at 100% (i.e., maximum).

**Note 2:** In the event that, even after repeated "successful" calibration attempts, the RF burst does not start and end smoothly at the verification settings described above, it is possible that the phase detector module in your RAM-5000 system is itself significantly out of calibration. Please contact customer support for help.

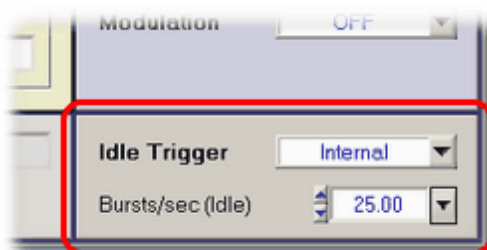
### Calibration Data:

The calibration data is presently stored as part of the RAM5K driver session settings, which are independently kept from any user data (settings) files. RAM-5000 instrument setup files, whether they are created as part of some data acquisition run, or alone for retrieval at a later time, store only the DC offset control voltage and, if currently using the calibrated control mode, the desired DC Offset control value in percent.

That means, when you load RAM-5000 data files or just set files that were created prior to calibrating into the RAM-5000-SNAP User Interface, the original DC offset control voltage settings are automatically converted if the active control mode is in percent.

That also means, you can switch back and forth between the calibrated and the uncalibrated DC offset control mode without necessarily discarding the calibration data stored on your system. To switch, you right-click over the offset control and then select either **Change control values into D/A Ctrl-Volts** or **Change control values into calibrated Percent** from the context menu. And if you do not see the menu item **Change control values into calibrated Percent**, then your system either has not yet been calibrated or needs to be recalibrated.

## 4.5 Trigger



*Idle Trigger Panel*

This group of controls is for setting up general-purpose, or *idle*, triggering. The Idle Trigger controls are for setting up a trigger which is used when the instrument is in the *idle* state, that is, when no data is acquired. For example, the Idle Trigger may be used to monitor certain waveforms on an oscilloscope while optimizing instrument setup parameters. Whenever data acquisition is activated, the Idle Trigger is automatically deactivated, but immediately resumes trigger control when data acquisition is stopped or has finished (for example, when scanning). To set, for example, the burst rep-rate that would be applicable during a measurement, use the trigger controls located on the Acquisition Control Panel <sup>6-31</sup>.

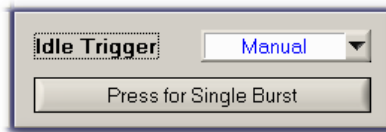
Depending on the selected **Trigger Source**, either a single burst may be triggered **Manually**, or a burst repetition rate (**Rep-Rate**) value may be specified for continuous triggering. If the Trigger Source is set to **External**, neither option will be available. More details on the various Trigger settings are described below:

- Trigger Source [4-28](#)
- Manual Trigger [4-29](#)
- Burst Rep-Rate [4-29](#)
- External Trigger [4-30](#)

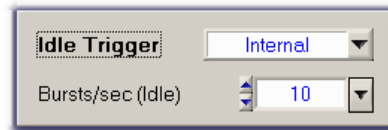
### 4.5.1 Trigger Source

Standard settings: Manual, Computer, Internal, or External

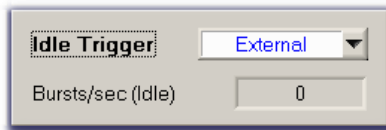
This control [3-14](#) is for setting the source of the *idle* trigger.



Setting the trigger source to **Manual** [4-29](#) enables a push button below the source control. This push button is used for launching a single burst when desired.



Setting the trigger source to **Computer** or **Internal** enables a rep-rate control [4-29](#) below the source control for selecting the desired trigger repetition rate. Continuous triggering will begin at the set rep-rate as soon as either source is selected. The rep-rate setting may be changed at any time.



Setting the trigger source to **External** enables a rep-rate monitor [4-30](#) gauge below the source control for the display of the effective trigger repetition rate as configured externally. The rep-rate monitor will show a reading as soon as a trigger event is registered by the user interface software via the RAM-5000-SNAP hardware. Initially, the rep-rate reading may change quite a bit until a sufficient number of trigger events have been registered for a stable mean value. This trigger source setting is useful when control of the RAM must be synchronized with other instruments, and the RAM cannot be used as the master trigger source.

**Note:** When external triggers are employed, the RF burst will still be coherent with respect to the CW because the amplifier gate must wait for a positive-going zero-crossing

of the RF switching on or off. If the oscilloscope or other device is triggered from the external trigger, jitter may be experienced in the display of the RF burst. However, the "TRIGGER OUT" of the RAM-5000-SNAP will remain coherent with both the RF and the burst.

#### 4.5.2 Manual Trigger

Pressing the button will trigger the generation of a single RF burst. Typically, a single trigger event is sufficient to update the display of an oscilloscope. Using the Manual Trigger control instead of a repetitive triggering scheme can be of great benefit when operating the gated amplifier at a high-power output level, and/or when working with a delicate experimental setup.

#### 4.5.3 Burst Rep-Rate

Nominal range: 0.01 to 1000 Hz Computer and 0.1 to 10,000 Hz Internal

This control is for setting the idle (as opposed to data acquisition) burst rep-rate when the Trigger Source control is set to **Computer** or **Internal**.

If the trigger source control is set to **Computer**, a software-controlled asynchronous trigger timer is employed. The usable rep-rate values are subject to the timer limitations which has a resolution of 1 ms. The maximum achievable rate is dependent upon other operating conditions of the instrument (see below). The rate accuracy is subject to varying CPU load conditions of the User Interface host computer, as a result of the multi-tasking computer operating system. In general, the higher the rate setting, the less accurate the effective rep-rate may become. However, under normal operating conditions, the slight fluctuations in the burst repetition timing are negligible. If a deterministic and reliable rep-rate is needed, the trigger source control should be set to *Internal*.

If the trigger source control is set to **Internal**, the usable rep-rate values are subject to the hardware duty cycle limitations. However, a large number of fixed internal repetition rates are available. The internal trigger rep-rate generator is highly deterministic and its accuracy is independent of the user interface host computer's other activities.

**Note:** The step size setting for the trigger rep-rate control is handled automatically by the RAM-5000-SNAP user interface and may not be adjusted by the user. The step size is increased or decreased as a function of the rep-rate value. That is, the larger the rep-rate, the larger the step size will be.

If the Trigger Source control is set to any setting other than *Manual*, the rep-rate parameter needs to be chosen in conjunction with the Burst Width and the gated amplifier Output Level to insure a clear waveform presentation on the oscilloscope without exceeding the duty-cycle limitation of the RAM-5000-SNAP hardware. The relationship is:

$$\text{Duty - Cycle (\%)} = \text{Burst Width (\mu sec)} \times \text{Rep - Rate (Hz)} \times 10^{-4}$$

The user interface software will automatically check the duty cycle whenever the repetition rate or the burst width is changed. If the specified duty cycle limit would be exceeded with the change, the software will reduce the repetition rate to bring the duty cycle within the specified limit. Normally this limit is 0.3%. Please be aware that the power ratings of RITEC accessories may vary.

#### 4.5.4 External Trigger

This indicator is for monitoring the externally (typically hardware-controlled) generated trigger repetition rate and the external triggering status.

While externally generated trigger events can be registered up to rates as high as 1 kHz, the rep-rate monitor display will be updated at a maximum rate of only 5 Hz.

**Note:** At rates higher than 1 kHz, the rep-rate monitor will no longer work. However, the RAM-5000-SNAP may still be triggered (and will generate pulses) at higher rates if possible. That is, the external rep-rate is subject to the duty-cycle limitation of the instrument, and needs to be chosen carefully. For additional information, please see the documentation Rep-Rate [\[4-29\]](#) control.

The external trigger rep-rate monitor also includes a green LED, located immediately next to the rate readout. The LED provides an additional visual indication of the external trigger rate and status. Thus, the color of the LED is reset to *green* with each newly registered external trigger event and gradually changes to the color *black* over a period of about 5 seconds. That means, a *black* LED means either no trigger has yet occurred, or the most recent trigger has occurred more than 5 seconds ago. The LED may be useful when either the rate is low and very stable (so that the displayed rate value never changes) or the high-voltage is turned off (so that the hardware LED above the high-power output BNC [\[11-2\]](#) on the RAM-5000-SNAP front panel is not activated).

# Section 5

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*Signal Detection*



## 5 Signal Detection

This section describes the controls that are located on the Receiver tab of the RAM-5000-SNAP User Interface.

- Input [5-2](#)
- Amplifier [5-3](#)
- Detector [5-4](#)
- Integrators [5-8](#)

### 5.1 Receiver Input



*Receiver Input Controls*

The Input controls of the RAM-5000-SNAP Receiver setup are described below:

- Input Enable [5-2](#)
- Input Channel [5-2](#)

#### 5.1.1 Input Enable

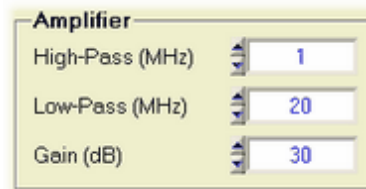
This toggle switch is for quickly disabling or enabling the input to the Receiver. This function is useful when performing oscilloscope or internal background signal diagnostics.

#### 5.1.2 Input Channel

*Standard options: Channel 1, and Channel 2. For the number of channels in your RAM-5000-SNAP refer to the **Specifications** in the Appendices [13-2](#).*

This control [3-14](#) is for setting the active Receiver Input Channel.

## 5.2 Receiver Amplifier



Receiver Amplifier Controls

The Amplifier controls of the RAM-5000-SNAP Receiver setup are described below:

- High-Pass Filter [5-3](#)
- Low-Pass Filter [5-3](#)
- Gain [5-3](#)

### 5.2.1 High-Pass Filter

*Standard settings: 0.1, 1, or 4 MHz. For the settings of your RAM-5000-SNAP refer to the **Specifications** in the Appendices [13-2](#).*

This control [3-14](#) is for setting the active RF high-pass filter frequency in the Receiver Amplifier module.

This filter should be set to as high a frequency as possible but below the lowest frequency of operation during a measurement. This will minimize the recovery time.

### 5.2.2 Low-Pass Filter

*Standard settings: 20, 40, or 80 MHz. For the settings of your RAM-5000-SNAP refer to the **Specifications** in the Appendices [13-2](#).*

This control [3-14](#) is for setting the active RF low-pass filter frequency in the Receiver Amplifier module.

This filter should be set above the highest frequency of operation during a measurement. Its purpose is to reduce noise and reject out of band signals.

### 5.2.3 Gain

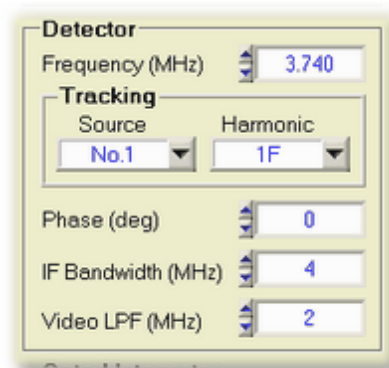
*Standard range: 22 to 100 dB in 2-dB steps*

This control [3-14](#) is for setting the receiver signal gain.

Please note, the Receiver Gain setting represents the combined (total) signal gain through the various receiver modules (RF and IF amplifiers, etc.). The level of signal amplification

that may be measured at the available receiver monitor and receiver signal output connectors is always 12 dB lower than the Gain control will indicate. That means, a setting of about 32 dB effectively results in an apparent 0-dB amplification between the RF input signal and RF signal at the RECEIVER RF MONITOR [11-31](#) (-20dB) point, while the same gain setting would result in 20-dB amplification between the RF input signal and the RECEIVER OUTPUT [11-61](#) signal.

## 5.3 Superheterodyne Detector



*Heterodyne Detector Controls*

The superheterodyne (narrowband) detector controls of the RAM-5000-SNAP Receiver setup are described below:

- Frequency [5-4](#)
- Frequency Tracking [5-5](#)
- Phase [5-7](#)
- IF Bandwidth [5-7](#)
- Video Low-Pass Filter [5-7](#)

### 5.3.1 Frequency

*Nominal range:* 0.02 to 80 MHz in 1-Hz steps. For the range of your RAM-5000-SNAP refer to the **Specifications** in the Appendices [13-21](#).

This control [3-14](#) is for setting the frequency at which a received signal is to be analyzed in the superheterodyne detector.

**Note:** The detector frequency setting controls the frequency of the third Synthesizer, which is mixed with the received RF signals to generate the intermediate frequency, (IF). The setting of the detector frequency will determine what RF frequencies are observed at the output of the entire superheterodyne receiver. As shown in the block diagram [10-21](#), the actual frequency programmed into the synthesizer is the detector frequency plus 20 MHz.

If the active receiver Tracking [5-5](#) is set to either a Sum or a Difference frequency, the frequency value may not be edited or changed directly. This control state is indicated by the lack of the small arrow buttons normally located on the left side of the control. When the arrow buttons are missing, a small "lock" icon may be shown instead, which also functions as a toggle button for *locking* the detector frequency. This option is not available in combination with Multi-Frequency Tracking [6-27](#) or Modulation [4-10](#) ("lock" icon/button is not shown). The meaning of the detector frequency lock is as follows: In the unlocked state, you may adjust the receiver frequency setting by changing either of the two source frequency settings. In the locked state, the receiver frequency setting may not be changed, and instead changing either of the two source frequency settings changes the value of the other according to the active receiver tracking setting. This applies when performing interactive as well as scanned data acquisition, that is Frequency Scanning [6-9](#).

### 5.3.2 Tracking

This group of controls is for setting the Receiver Frequency Tracking options. If Tracking is enabled, that is for any Tracking Source [5-5](#) setting other than NONE, the receiver frequency and the frequency of the selected Tracking Source are locked with respect to each other. That means, if the source frequency is changed, the receiver frequency automatically updates according to the Tracking Frequency [5-6](#) setting. Conversely, if the receiver frequency is changed, the source frequency automatically updates accordingly.

Tracking may be set up for each *defined* signal set [6-29](#) individually, by first unlocking it and making it a set-to-set variable [6-30](#).

If Multi-Frequency Tracking [6-27](#) has been set up, the tracking Frequency ("Harmonic"/"Comb.Frq.") control has a slightly different purpose and functionality. In this case, the list of frequencies, which is determined via the Multi-Frequency Tracking Setup [6-28](#) dialog, will no longer show all possible, but only the set up tracking frequencies. Selecting a frequency from this list does not redefine tracking but only selects this frequency for monitoring its value in the detector frequency [5-4](#) control. Selecting the additional list item labeled "**More...**" opens the Multi-Frequency Tracking Setup dialog. The tracking Source control functions similar to the case of single-frequency tracking. Selecting a different source value, updates the tracking Frequency control with the list of defined frequencies for the selected source.

#### 5.3.2.1 Source Control

Standard options: NONE, No.1, No.2, or BOTH

This control [3-14](#) is for setting the receiver Tracking Source synthesizer.

The receiver Tracking Source control determines which source frequency is used to set the receiver frequency.

If the source control is set to **NONE**, tracking is disabled, and any receiver frequency [5-4](#) within the allowed range may be selected without changing any of the source frequencies.

If the source control is set to **No.1** or **No.2**, tracking is enabled, and the receiver frequency setting is locked with respect to the operating frequency of Source 1 or Source 2, respectively, based on the Tracking Frequency  $\sqrt{5-6}$  setting.

If the source control is set to **BOTH**, tracking is enabled, and the receiver frequency setting is locked with respect to the sum of or difference between the operating frequencies of Source 1 and 2, based on the Tracking Frequency  $\sqrt{5-6}$  setting.

### 5.3.2.2 Frequency Component

Standard options: 1F, 2F, 3F, 4F, 5F, SumF, or DifF (see Multi-Frequency Tracking  $\sqrt{6-27}$  for advanced options)

This control  $\sqrt{3-14}$  is for setting the Tracking Frequency of the detector.

Control of the receiver frequency is determined by the Tracking setting according to the following:


1. If the tracking frequency is set to **1F**, and the tracking source is set to **No.1**, the receiver frequency will "track" the frequency of Source 1, and cannot be changed independently. Attempts to change the receiver frequency will also change the frequency of Source 1. (A 0.3 MHz change in the receiver frequency will result in a 0.3 MHz change in the frequency of Source 1.)
2. If the tracking frequency is set to **2F**, the receiver frequency will be set to twice the frequency of Source 1, and cannot be changed independently. Attempts to change the receiver frequency will result in changes to Source 1, but at one-half the magnitude. (A 0.3 MHz change in the receiver frequency will result in a 0.15 MHz change in Source 1.)
3. If the tracking frequency is set to **3F**, the receiver frequency will be set to three times the frequency of Source 1, and cannot be changed independently. Attempts to change the receiver frequency will result in changes to Source 1, but at one-third the magnitude. (A 0.3 MHz change in the receiver frequency will result in a 0.1 MHz change in Source 1.)
4. If the tracking frequency is set to **DifF**, the receiver frequency will be set to the difference frequency corresponding to the difference between the frequency of Source 1, and the frequency of Source 2. The receiver frequency cannot be changed independently.
5. If Multi-Frequency Tracking  $\sqrt{6-27}$  is used, the receiver frequency will be set according to the option chosen from the tracking frequency ("Harmonic"/"Comb.Frq.") control's drop-down menu and the associated tracking as defined on the Multi-Frequency Tracking Setup  $\sqrt{6-28}$  dialog.


### 5.3.3 Phase

Nominal range: 0 to 360 deg in 0.022-deg steps (14-bit resolution)

This control  is for setting the relative phase in degrees of the local oscillator signal.

### 5.3.4 IF Bandwidth


Standard settings: 0.4, 1, or 4 MHz. For the settings of your RAM-5000-SNAP refer to the **Specifications** in the Appendices .


This control  is for setting the bandwidth or band-pass filter frequency for the IF mixer signal.

Reducing the IF bandwidth will reduce the noise but may distort some signals if the detected signal contains high video frequency components. This may occur when receiving signals produced by very short RF bursts. A useful guideline relationship between the required bandwidth and the burst width is given by:

$$\text{Bandwidth (MHz)} > \frac{3}{\text{Burst Width } (\mu\text{s})}$$

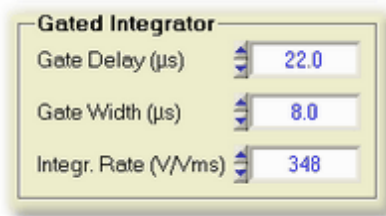
### 5.3.5 Video Low-Pass Filter

Standard settings: 0.05, 0.1, 0.15, 0.25, 0.4, 0.7, 1, or 2 MHz. For the settings of your RAM-5000-SNAP refer to the **Specifications** in the Appendices .

This control  is for setting the Phase-Detector video low-pass filter frequency.

The outputs of the phase-sensitive detectors are filtered by selectable low-pass filters. This filtering is of value mainly for oscilloscope observations of the detected signals. Under most circumstances, the integrators are more effective than the filters in removing high-frequency noise. Because the low-pass filters may lengthen the time duration of a short signal, care must be taken to include all of the signal when positioning the integrator gate. For this reason, it is prudent to make computer measurements with a minimum of video filtering (highest frequency setting). The integration of the phase-detected signal provides additional low-pass filtering.

## 5.4 Gated Integrators



*Gated Integrator Controls*

The gated integrator controls of the RAM-5000-SNAP Receiver setup are described below:

- Gate Delay [5-8](#)
- Gate Width [5-8](#)
- Integration Rate [5-8](#)

### 5.4.1 Gate Delay

*Nominal range:* 1.1125 to 6550  $\mu\text{s}$  in 12.5-ns steps. For the range of your RAM-5000-SNAP refer to the **Specifications** in the Appendices [13-2](#).

This control [3-14](#) is for setting the delay of the integration gate, that is, the start time of the integration with respect to the trigger time.

### 5.4.2 Gate Width

*Nominal range:* 0.1125 to 6550  $\mu\text{s}$  in 12.5-ns steps. For the range of your RAM-5000-SNAP refer to the **Specifications** in the Appendices [13-2](#).

This control [3-14](#) is for setting the width or length of the integration gate, that is, the end minus the start time of the integration.

### 5.4.3 Integration Rate

*Standard settings:* 0.454, 0.769, 1.36, 2.37, 4.12, 7.3, 12.2, 21.3, 37.0, 66.7, 110, 200, 350, 620, 1100, 2000 V/Vms. For the settings of your RAM-5000-SNAP refer to the **Specifications** in the Appendices [13-2](#).

This control [3-14](#) is for setting the integration rate.

The integration rate refers to the  $r_I$  constant which appears in Equations 10-8 [10-6](#) and 10-9 [10-6](#). This parameter is set in conjunction with the receiver gain so that the amplitude from the gated integrators will be between approximately 1 and 4.5 V for an optimum data acquisition dynamic range. The burst width and output level of the gated amplifier will also

affect the integrator levels. Outputs above 4.5 V may not be good linear representations of the signal and, therefore, are to be avoided.

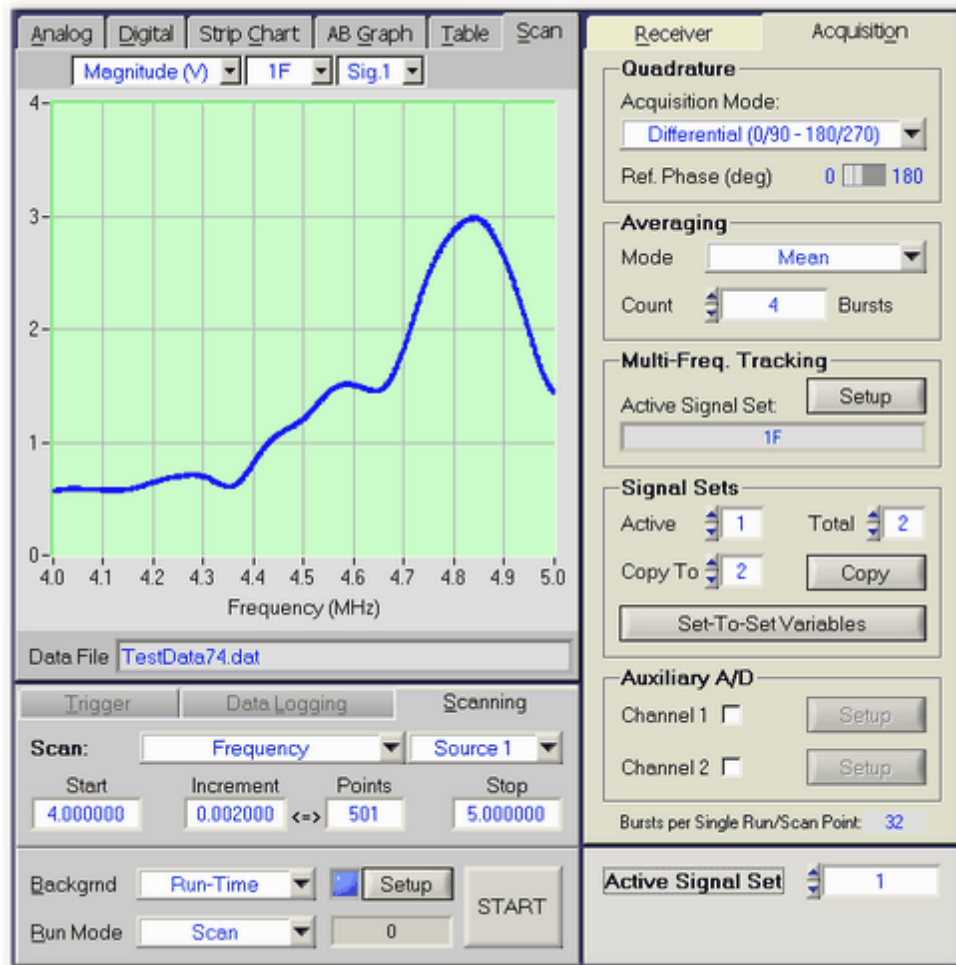


# Section 6

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*Data Acquisition*

## 6 Data Acquisition



This section describes the data acquisition related controls and options that are available with the RAM-5000-SNAP User Interface. For data visualization and analysis features, see the section entitled Data Display [7-2](#). For details on specific measurements, see section Making Measurements [8-2](#).

- Overview [6-2](#)
- Acquisition Control Panel [6-3](#)
- Acquisition Options [6-23](#)

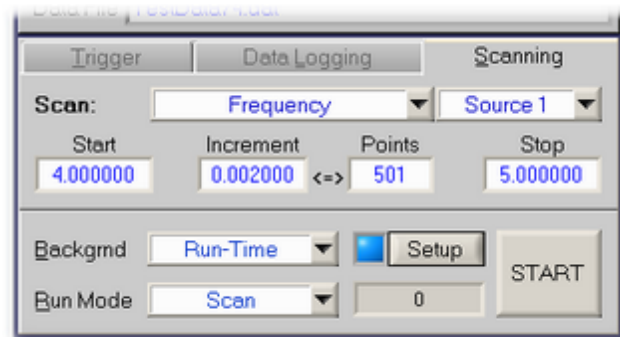
### 6.1 Overview

The RAM-5000-SNAP User Interface includes a wide range of data acquisition and data visualization capabilities. Some limited numeric data analysis capabilities are implemented as part of the measurement mini-modules (see Measurements Menu [3-6](#)).

The controls most frequently used when acquiring data, such as the acquisition Run Mode control and the RUN/START button, can be found on the Acquisition Control Panel [6-3](#), located directly below the various Data Display [7-2](#) panels of the user interface. Data acquisition options, such as to enable one of the Auxiliary A/D Channels and the Quadrature Mode control are located on the Acquisition Panel [6-23](#), located behind the Receiver Controls Panel. All scanning related data acquisition controls are located on the Scan Panel [6-8](#), which can be found among the Data Display panels, as it also contains the scan data view graph.

In the RAM-5000-SNAP user interface, a complete data acquisition *cycle*, or measurement data point, may consist of numerous individual integrator data read events, each requiring a burst to be triggered. A single integrator data read event acquires the in-phase and the 90-degrees out-of-phase (quadrature) signal components at the selected Reference Phase [6-24](#) setting. If the Quadrature Acquisition Mode [6-24](#) is set to *Differential*, each integrator data read event comprises two single read events 180-degrees out of phase, thus a total of two burst launches. The data acquisition Trigger Rep-Rate [6-5](#) setting determines the time between any two consecutive burst launches, regardless of what type of scan or measurement configuration is being executed. For example, a single measurement point may comprise 10 differential integrator data readings (= 20 triggered bursts), for two defined signal settings, each including two receiver tracking frequencies. This results in a total of 80 burst triggers each followed by a single integrator data read event.

## 6.2 Acquisition Control Panel



The Acquisition Control Panel when Frequency scanning.

The data Acquisition Control Panel is located below the various data display tabs, and contains the controls most frequently used when acquiring data. These controls are organized into the following five groups:

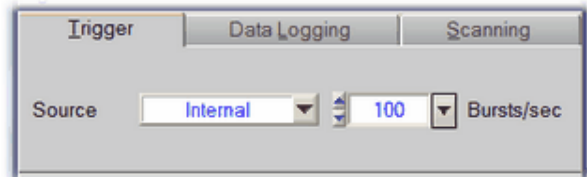
- Trigger [6-4](#)
- Data Logging [6-6](#)
- Scanning [6-8](#)
- Background [6-15](#)
- Run Modes [6-20](#)

## 6.2.1 Trigger

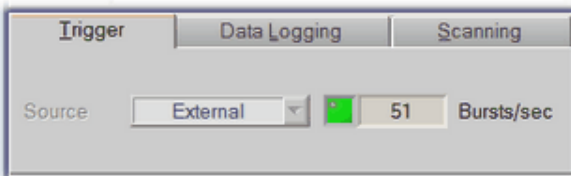
The trigger setup comprises two controls, the Trigger Source [6-4](#) and the Burst Rep-Rate [6-5](#). Depending on the selected Trigger Source, a single burst may be triggered *Manually*, or a Rep-Rate value may be specified for continuous triggering. If the Trigger Source is set to External [6-6](#), neither option will be available, but instead a rep-rate monitor is shown.



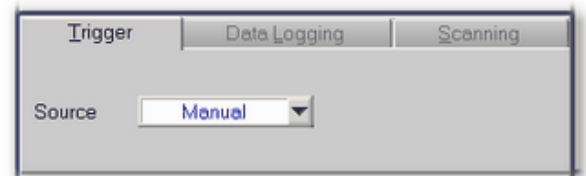
*The Trigger tab when triggering continuously using a software timer.*



*The Trigger tab when triggering continuously using the hardware rep-rate clock.*



*The Trigger tab when triggering externally during data acquisition.*



*The Trigger tab when triggering manually.*

**Note:** These trigger controls are to be used only for the purpose of setting up data acquisition timing. To set up a trigger for any other purpose, for example, to monitor waveforms on an oscilloscope while optimizing an instrument setup, the Idle Trigger [4-27](#) should be used.

### 6.2.1.1 Trigger Source

This control [3-14](#) is for setting the source of the data acquisition burst trigger.

Setting the trigger source to **Computer** or **Internal** enables a rep-rate control [6-5](#) next to source control for selecting the desired trigger repetition rate.

Setting the trigger source to **External** enables a rep-rate monitor [6-6](#) gauge next to the source control for the display of the effective trigger repetition rate as configured externally. The rep-rate monitor will show a reading as soon as a trigger event is registered by the user interface software via the RAM-5000-SNAP hardware once data acquisition has been initiated. At first, the rep-rate reading may change quite a bit until a sufficient number of trigger events have been registered for a stable mean value. This trigger source setting is useful when control of the RAM must be synchronized with other instruments, and the RAM cannot be used as the master trigger source.

**Note:** When external triggers are employed, the RF burst will still be coherent with respect to the CW because the amplifier gate must wait for a positive-going zero-crossing of the RF switching on or off. If the oscilloscope or other device is triggered from the external trigger, jitter may be experienced in the display of the RF burst. However, the "TRIGGER OUT<sup>11-6</sup>" of the RAM-5000-SNAP will remain coherent with both the RF and the burst.

If the data acquisition Run Mode<sup>6-20</sup> is set to *Single*, one more trigger option becomes available, **Manual**, which is mainly to be used for diagnostic purposes or other special cases. In this trigger mode, you have full control over every single burst and subsequent data acquisition event. This means, if mean averaging is enabled, for example, you would have to hit the "RUN" button repeatedly until the set averaging count value has been reached for the final data value to be calculated and displayed.

**Note:** If both Auxiliary A/D channels are enabled, please note that it requires a separate trigger event to read each channel.

### 6.2.1.2 Burst Rep-Rate

This control<sup>3-14</sup> is for setting the data acquisition burst rep-rate when the Trigger Source<sup>6-4</sup> control is set to **Computer** or **Internal**.

The rep-rate value determines how fast an entire data acquisition *cycle* may be processed. For example, if mean averaging<sup>6-25</sup> is used, with an averaging count control value of 10, and 2 signal settings<sup>6-29</sup> that have been set up with 2 receiver tracking<sup>5-5</sup> frequencies per signal setting, then it would require a rep-rate of 40 bursts per second to obtain final data values once every second, provided the Quadrature Acquisition Mode<sup>6-24</sup> is set to *Standard*. Using the *Differential* Quadrature Acquisition Mode would immediately double the required rep-rate. This suggests that one would always want to set the rep-rate at a high value to obtain efficient measurement performance if using long averaging and/or complex data acquisition scenarios. However, caution must be exercised when using high rep-rates, especially when operating the gated amplifier at a high power output level.

The RAM-5000-SNAP User Interface software will automatically check the duty cycle whenever the repetition rate or the burst width is changed. If the specified duty cycle limit would be exceeded with the change, the software will reduce the repetition rate to bring the duty cycle within the specified limit. Normally this limit is 0.3%. Please note, most of the RITEC attenuators, diplexers, and other accessories are limited to a 0.1% duty cycle at the maximum 5 KW output.

**Note:** The step size setting for the trigger rep-rate control is handled automatically by the RAM-5000-SNAP User Interface and may not be adjusted by the user. The step size is increased or decreased as a function of the rep-rate value. That is, the larger the rep-rate, the larger the step size will be.

When the trigger source control is set to **Computer**, a software-controlled trigger timer is employed. The usable rep-rate values are subject to the timer limitations which has a

resolution of 1 ms. A truly deterministic timer performance is not possible with a multi-tasking computer operating system. Therefore, a special software algorithm has been implemented which monitors timer accuracy with respect to the set rep-rate and adjusts this rep-rate if necessary. As a result, the rep-rate may be lowered automatically by the user interface software to decrease the frequency with which timer events fail to occur when they should. To minimize the occurrence of such automatic rep-rate adjustments it is recommended to not use the computer for any other tasks during data acquisition.

When the trigger source control is set to **Internal**, a hardware-controlled trigger timer is employed, which is highly deterministic. Please note, however, the achievable data acquisition rep-rate accuracy may be impaired at settings higher than 250 Hz, or when frequently or rapidly changing a RAM-5000-SNAP instrument parameter of operation, such as burst frequency.

### 6.2.1.3 External Trigger

This indicator is for monitoring the externally (typically hardware-controlled) generated trigger repetition rate and the external triggering status.

While externally generated trigger events can be registered up to rates as high as 1 kHz, the rep-rate monitor display will be updated at a maximum rate of only 5 Hz.

**Note:** At rates higher than 1 kHz, the rep-rate monitor will no longer work. However, the RAM-5000-SNAP may still be triggered (and will generate pulses) at higher rates if possible. That is, the external rep-rate is subject to the duty-cycle limitation of the instrument, and needs to be chosen carefully. For additional information, please see the documentation Rep-Rate [\[4-29\]](#) control.

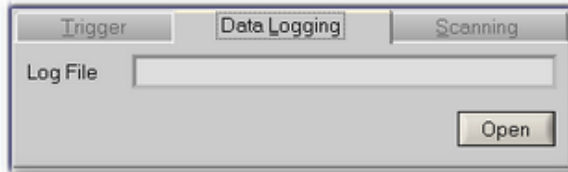
The external trigger rep-rate monitor also includes a green LED, located immediately next to the rate readout. The LED provides an additional visual indication of the external trigger rate and status. Thus, the color of the LED is reset to *green* with each newly registered external trigger event and gradually changes to the color *black* over a period of about 5 seconds. That means, a *black* LED means either no trigger has yet occurred, or the most recent trigger has occurred more than 5 seconds ago.

**Tip:** Use the Trigger Source setting **Internal** when configuring and testing setup of External data acquisition triggering. Both, Internal and External triggering make use of the same data acquisition software submodule. That means, you can use the Internal trigger to set up and test performance of the RAM-5000-SNAP User Interface at a certain rep-rate before switching to External where the external rep-rate generator is running at the same rate.

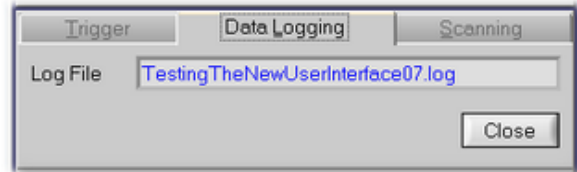
## 6.2.2 Data Logging

In acquisition Run Modes [\[6-20\]](#) *Single*, *Auto*, and *Continuous*, interactively acquired data can be stored in a log file [\[6-7\]](#). A new log file can be initialized by pushing the button labeled **Open**

next to the filename indicator. This button is disabled (dimmed) while data acquisition is in progress. If Run Mode *Continuous* is used, data acquisition will have to be stopped first, and restarted once a log file has been specified/created in the file browser dialog. Once a log file is open, the **Open** button changes its label to **Close**, indicating that this button may now be used to close the log file, and thus terminate logging to this particular file. Similarly, closing a log file may be done at any time except while data acquisition is in progress.



The Data Logging tab when logging is disabled.



The Data Logging tab when logging is enabled.

Data logging offers a flexible and powerful alternative to scanning [6-8](#), especially if used in conjunction with Run Mode *Auto*. Thus, you could perform various types of semi-automatic custom scans, by manually stepping through a range of instrument settings, whereby each new setting is automatically followed by a full data acquisition *cycle*, which may also be automatically recorded in a log file.

### 6.2.2.1 Log File Format

A RAM-5000-SNAP data log file is a space-delimited ASCII file with a single text header line labeling the various data columns. The left-most column contains the time stamp data, which is followed by the columns comprising all the acquired and/or processed data belonging to this measurement *point*. That means, one row or line of a data file contains all the data associated with a single measurement point. Depending on the configured Acquisition Options [6-23](#), a RAM-5000-SNAP data log file can contain many columns of data. Yet additional columns could comprise the respective standard deviation data [3-13](#), as well as certain measurement data [8-2](#).

The time stamp is created when all data for one measurement point has been collected, that is, at the completion of a single acquisition *cycle* (see Data Acquisition Overview [6-3](#) for more information on what comprises a data acquisition cycle).

Dependent upon the active acquisition Run Mode [6-20](#), the time stamp data is formatted in one of two ways:

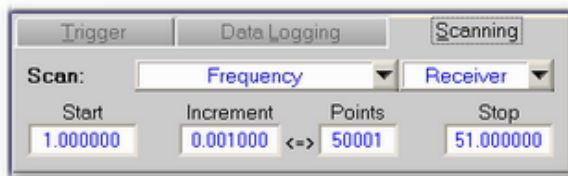
In the Run Modes *Single* and *Auto*, the time-of-day format *HH:MM:SS.MS* (Hour:Minute:Second.Milliseconds) is used. The date portion of the time stamp data for the first logged measurement point is stored as part of the column label in the header. The column label is of the format "TimeOfDay(*yyyy/mm/dd*)", where *yyyy*, *mm*, and *dd* represent the year, the month of the year, and the day of the month, respectively.

In Run Mode *Continuous*, the time stamp is formatted as *Seconds.Milliseconds* and represents the time relative to when data acquisition was started. Thus, the first logged

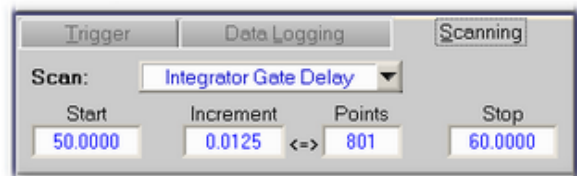
measurement point will have the relative time stamp data of "0.0". Its absolute time stamp data is stored as part of the column label in the header, in the format "TimeSince(HH:MM:SS\*yyyy/mm/dd)".

**Note:** Changing the Run Mode and restarting data acquisition without first closing a previously opened log file is allowed and will not change the time stamp format used for the additionally recorded measurement data. Whichever Run Mode is selected when finally closing the log file will determine the time stamp format used when writing out the ASCII file representation of all logged data.

### 6.2.3 Scanning



Example of a Receiver Frequency scan setup.



Example of an Integrator Gate Delay scan setup.

The tab labeled *Scanning* contains various controls related to scanned data acquisition. On this tab, you may set up a variety of automated data acquisition runs, in which one particular instrument control parameter is successively stepped through a user-defined range of values. To view the data acquired during or following a scan (or after reloading), please see the Scan Graph [7-14](#) documentation.

**Note:** Throughout the RAM-5000-SNAP documentation, the terms *scanning* and *scan* are used interchangeably with the terms *sweeping* and *sweep*, respectively, and refer to the same mode of instrument control combined with automatic data acquisition.

Some type of scanning is often the basis of a particular measurement. In many cases you can perform more types of measurements [3-6](#) than are available as a predefined procedure, simply by setting up and executing one of several possible scan scenarios to obtain the required raw data.

The controls for setting up a scan are described in detail below:

- **Scan:** Type [6-8](#) | Source/Receiver [6-12](#)
- Range Parameters [6-13](#) - *Start, Increment, Points, Stop*

#### 6.2.3.1 Scan Type

This control is used for selecting the type of scan that is to be performed, for example, a Frequency Scan. The associated drop-down menu lists the various scan *types* that are available.



The standard scan types allow for scanning the **Frequency** of either source <sup>[4-3]</sup> or of the receiver <sup>[5-4]</sup>, and for scanning the **Integrator Gate Delay** <sup>[5-8]</sup>. The scan type **Relative Time** allows for performing timed data acquisition, that is, for acquiring any type of data <sup>[7-17]</sup> as a function of time.

In the Advanced Edition of the RAM-5000-SNAP User Interface, the following additional scan types are available. These allow for scanning the **Phase** of either source <sup>[4-5]</sup> or of the receiver <sup>[5-7]</sup>, as well as the **Amplitude** <sup>[4-6]</sup> (Synthesizer Output Level), the **Gated Amp. Output Level** <sup>[4-8]</sup>, and the **Burst Delay** <sup>[4-5]</sup> of either source. The scan type **User-Defined** allows for acquiring data as a function of an arbitrary parameter.

Selecting a scan type automatically updates the available options associated with the Source/Receiver <sup>[6-12]</sup> control, which is located next to the Scan Type control.



As in the case of interactive data acquisition (run modes <sup>[6-20]</sup> *Single, Auto, and Continuous*), if multiple signal settings <sup>[6-29]</sup> and/or multiple receiver tracking frequencies <sup>[6-27]</sup> are set up, all of them will be taken into account as part of a complete data acquisition *cycle* at each scan point, regardless of the chosen Scan Type. However, if the signal settings and/or tracking frequency configuration contain a particular component that is incompatible with the chosen Scan Type, this component will simply be ignored during the scan. For example, suppose two signal settings have been configured, each with a different tracking frequency and integrator gate delay setting. For interactive data acquisition, signal setting 1 acquires data at one tracking frequency for the first integrator gate delay, whereas signal setting 2 acquires data at another tracking frequency for the second integrator gate delay setting. You then decide to perform an Integrator Gate Delay scan without reconfiguring the list of Set-To-Set Variables <sup>[6-30]</sup>, that is to disable the integrator gate delay as a variable between both signal settings. While the Integrator Gate Delay scan is executing, both signal settings will use the same integrator gate delay setting which will be locked to the scan range. Either signal setting will still each acquire a different tracking frequency.

Additional details on each particular Scan Type are described below:

- Frequency <sup>[6-9]</sup>
- Phase <sup>[6-10]</sup>
- Amplitude <sup>[6-10]</sup>
- Gated Amp. Output Level <sup>[6-10]</sup>
- Burst Delay <sup>[6-10]</sup>
- Integrator Gate Delay <sup>[6-10]</sup>
- Relative Time <sup>[6-10]</sup>
- User-Defined <sup>[6-11]</sup>




If a **Frequency** scan of either source is to be executed with receiver Frequency Tracking <sup>[5-5]</sup> set to track a frequency other than the fundamental, care needs to be exercised when viewing and interpreting the acquired data at this tracking frequency. Even though a particular data point may appear to have been acquired at, say, 5.0 MHz, this reference only applies to the *drive* frequency, and not the actual acquisition (detector) frequency. If the second

harmonic (2F) were being tracked, the particular data point is actually also associated with 10.0 MHz. This is relevant and needs to be kept in mind, especially when viewing a spectral distribution at some higher harmonic. In addition, the frequency increment (spacing) is by default larger at a higher harmonic, that is, it is effectively multiplied by the applicable frequency factor. If a scan over a range of receiver (detector) frequencies is to be performed, Frequency Tracking is automatically disabled, and neither source frequency will be changed automatically.

When receiver Frequency Tracking is set to track either a Sum or a Difference frequency, and the Detector Frequency  control has been *locked*, scanning the frequency of Source 1 automatically scans the frequency of Source 2, and vice versa. For example, if the detector is set to track some difference frequency value, and if the Frequency of Source 1 is the scan parameter, the frequency of Source 2 is scanned as well to maintain the set difference frequency. A second X axis is shown at the top of the Scan Graph  which reflects the range of the secondary frequency scan. The frequency labels on this X axis may appear in the color red when the sum or difference tracking frequency setting in conjunction with the primary frequency scan range would force certain secondary frequencies out of the range of operation. If this occurs, a scan can not be initiated until the various settings have been corrected, which will be indicated by black frequency labels on the top X axis of the Scan Graph.

The **Phase** scan will always be based on a range of phase values in the unit *degrees*, regardless of which unit is chosen for the display of acquired phase data. Due to hardware limitations, the **Increment** as well as the **Stop** value may result in somewhat "odd" numbers, as they are purposefully not rounded to a lower precision.

The **Amplitude** (Synthesizer Output Level) scan provides an auxiliary method to ramping the burst amplitude, which is done at the low-level stage (synthesizer) before the source signal enters the high-power gated amplifier. The range values always represent a percentage of the full scale (%-FS), where the maximum or full scale is determined by the gated amplifier settings. Due to hardware limitations, the scan range **Limits** may in certain cases only be set to "odd" numbers, as they are purposefully not rounded to a lower precision.

The **Gated Amp. Output Level** scan is the standard method for ramping the burst amplitude, which directly controls both the low- and high-power stages of a gated amplifier. With the Gated Amplifier Output Control  **ON**, the gated amplifier performance will be optimized at every level with respect to power output and burst shape characteristics, by automatically setting both the RF Level  and the Bias Level  control voltages.

In the **Burst Delay** scan, the start time of the respective high-power burst is successively changed with respect to the time of the trigger signal, and indirectly with respect to the start time (delay) of the integrator gate.

In the **Integrator Gate Delay** scan, the start time of the integrator gate is successively changed with respect to the time of the trigger signal, and indirectly with respect to the individual start times (delay) of either high-power burst.

In the **Relative Time** scan, the dependent variable is time relative to an arbitrary start time chosen by the user. When the time scan is initiated, an algorithm first tries to optimize various run parameters to obtain a reasonably accurate timer performance taking into

account current computer performance characteristics. For the first couple of time increments, data will be acquired but immediately discarded, which causes a slight delay in when the actual time scan measurements start. Since a truly deterministic timer performance is not possible with a multi-tasking computer operating system, a special algorithm monitors timer accuracy with respect to the measurement rep-rate and adjusts it if necessary. As a result, the rep-rate may fall below a value necessary to sustain the desired time increment in the time scan. If this occurs, the time scan automatically terminates with a notification message. Regardless of how accurate each individual time increment ultimately is during a particular scan, the software records the actual time increments along with the acquired data. The time increment chosen by the user represents a target value, which the RAM-5000-SNAP software attempts to achieve. In general, the resolution of the used timer is one millisecond, even though the **Increment** value is limited to a minimum of 100 milliseconds, as any smaller increment would be unfeasible (for increments smaller than 100 milliseconds, see Note #2 below). The time stamps recorded in a data file will be seconds from the *true* scan start in the form of a floating point number with 3 digits of precision, matching the timer resolution.

**Note:** When running a Relative Time scan, there are essentially two trigger rates. The first trigger increment is determined by the data acquisition burst rep-rate [6-5](#) setting, the second trigger increment is determined by your scan increment [6-13](#) setting. For example, consider a burst rep-rate of 200 Bursts/sec and a scan increment of 0.1 seconds. Now suppose you want to examine two echoes using the *Differential Quadrature Acquisition Mode* [6-24](#), which means there will be a total of four pulses per data point. In this scenario, every 0.1 seconds the pulse source will transmit 4 bursts at a rep-rate of 200 Bursts/sec. After these 4 pulses are transmitted, the pulse source will not transmit another burst until the next 0.1-second increment is reached, at which point another 4 pulses will be transmitted and so on.

**Note:** If you need to obtain a timed series of data points without the wait for a time increment to elapse, you might try using acquisition Run Mode *Continuous* in conjunction with Data Logging [6-6](#) as an alternative. In Run Mode *Continuous*, the timing of data acquisition is determined only by the burst rep-rate setting. However, please note, that a complete data acquisition cycle [6-3](#) would have to be finished in less than the minimum time increment of a Relative Time scan, for the alternative to be collecting data points at smaller time steps.

In a **User-Defined** or custom scan, the dependent variable is determined by the user, and is not necessarily a RAM-5000-SNAP instrument parameter of operation, such as burst frequency or amplitude. That is, the dependent variable in a user-defined scan may be, for example, the position of a mechanical scanner or the setting of a materials testing device. While there will be no programmatic connection between the RAM-5000-SNAP User Interface and the scanner or testing device, the user is provided with two scan point trigger options for establishing a connection in terms of timing. That means, the event that triggers a complete data acquisition cycle at each scan point may be a button click on the RAM-5000-SNAP User Interface or a certain voltage change at the TRIGGER IN [11-6](#) connector. The latter case requires a TTL signal and would allow for externally timed, automated data acquisition.

For a user-defined scan, the scan range and increment are specified, as for pre-defined scan types, using the Range Parameter [6-13](#) controls. In the case of a user-defined scan,

however, the range parameters define an empirical scan range and resolution, based on a measurement setup controlled elsewhere. That is, the *Start*, *Increment*, and *Stop* values are primarily used for the graphical representation of the acquired data, while the number of *Points* value determines after how many completed acquisition cycles the scan run in the RAM-5000-SNAP User Interface is supposed to end.

When selecting the scan type **User-Defined**, a button labeled "Setup" becomes visible next to the Scan Type control, and the burst trigger source [6-4](#) is automatically set to *Computer*. Clicking the Setup button opens a dialog for specifying additional scan customization options. On the dialog, the user specifies the Scan Parameter (dependent variable), which is used to name the scan graph X-axis. The Scan Point Trigger control setting determines whether each acquisition cycle is triggered *manually* by the user or triggered based on the *external* trigger signal timing sequence.

When a user-defined scan is initiated, the Idle Trigger [4-27](#) controls will change to the *run-time* Scan Point Trigger controls for the duration of the scan. That is, if the Scan Point Trigger setting is *Manual*, a button will be available that is used to trigger the start of one acquisition cycle. If the Scan Point Trigger setting is *External*, a trigger rate monitoring display will be available that operates similar to the external burst rep-rate monitor [4-30](#) for the Idle Trigger.

**Note:** Independent of the selected Scan Point Trigger, the burst rep-rate [6-5](#) setting controls the timing while a data acquisition cycle executes. During that time, neither the manual trigger button will be active, nor will the RAM-5000-SNAP instrument hardware be capable of sensing an external trigger. That means, when using the Scan Point Trigger setting *External*, the external rep-rate needs to be chosen low enough to allow for each acquisition cycle to be completed before the next trigger is scheduled to occur. Otherwise, the next trigger will simply be missed, and the effective external trigger rate for the user-defined scan will be half the target rep-rate or even lower, which can be seen on the external trigger rate monitoring display. Some experimentation may be required to determine optimum trigger settings etc. before successfully executing an externally triggered user-defined scan without intermittently missing a trigger. **DO NOT** make the "dead time" (the time between the completion of a DAQ cycle and the next scheduled external trigger) too tight.

### 6.2.3.2 Source/Receiver

This control is used for selecting one of the available sources, or Receiver, in conjunction with a particular Scan Type [6-8](#). For scan types *Frequency* and *Phase*, either one of the source synthesizers, or the receiver synthesizer, may be selected. For scan types *Amplitude*, *Gated Amp. Output Level*, and *Burst Delay*, only a source may be selected, in which case it either refers to a synthesizer or a gated amplifier. The scan types *Integrator Gate Delay*, *Relative Time*, and *User-Defined* do not involve a source/receiver selection, in which case this control will not be available.

### 6.2.3.3 Range Parameters

The scan range controls (Start, Increment, Points, and Stop), located immediately below the **Scan**: *type* selector control, are used to edit the desired range and increment settings for the selected scan type.

The scan range controls are all inter-connected. That means, changing the setting of any one of these controls causes at least one of the other controls to change its value as a result. For example, when you change the number of Points setting, the Increment setting will automatically be adjusted to maintain the Stop value setting. The functionality of each particular range control is described in the following:

- **Start** ... editable to within hardware limitations, changes the **Stop** value to maintain the current scan range. That is, the entire range is offset by the difference between the old and the new Start values. If the range is to be decreased or increased, adjust the **Stop** value accordingly, after you have set the Start value.
- **Increment** ... editable to within hardware limitations and to the nearest feasible value, while at the same time obtain a new valid Points value and maintain the exact same Stop value.
- **Points** - ... editable to the nearest feasible value, while at the same time obtain a new valid Increment value and maintain the exact same Stop value.
- **Stop** - ... editable to within hardware limitations and to the nearest feasible value, while at the same time obtain a new valid Points value and, if necessary, adjust the Increment value as little as possible to keep it close to its original setting.

**Note1:** None of the scan range controls has the pair of small arrow buttons, that is normally shown on the left side of a numeric control [\[3-14\]](#). However, you can still operate the scan range controls in a similar way using the up and down arrow keys on your keyboard. --- When changing the **Start** or **Stop** value using the up and down arrow keys, the step size used is always the Increment value. But, when using the up and down arrow keys for changing the **Increment** or **Points** value, the effective step size is dynamically determined to obtain the next valid Points or Increment value, respectively, while maintaining the same Stop value.

**Note2:** The Start, Increment, and Stop control values always share the same unit. And, although in the RAM-5000-SNAP User Interface there is no unit label directly associated with any of these controls, the applicable unit is displayed as part of the X-axis label on the Scan Graph [\[7-15\]](#). Also, the applicable unit is usually the same as is used for the instrument control parameter being scanned. However, when setting up a Relative Time scan the Increment and Stop control values may be edited in a number of different time formats. For additional information see Setting Time Format when performing time-dependent measurements [\[6-14\]](#).

**Note3:** The scan range controls can not be used to change the range of the displayed data (zooming). To zoom into a particular X-axis range, either use the X-Axis Properties [\[7-19\]](#) dialog, the Graph Properties [\[7-20\]](#) dialog, or zoom interactively (see Data Graph [\[7-16\]](#)). Changing any of the range parameters, clears the graph, as it is assumed that a new scan is being defined.

### Setting Scan Direction

Usually, a scan range is defined by having a Start value that is smaller, or lower, than the Stop value. However, you also can set up a scan that uses a Start value that is larger, or higher, than the Stop value. You do this by simply typing a minus sign in front of the the **Increment** value. Or, using the mouse, you can either left-double-click the Increment control or right-click the Start, Increment, or Stop control and chose *Reverse Scan Direction => Scan High to Low* from the context menu.

When the scan range is reversed, the Start and Stop values are merely interchanged without affecting other scan parameters. The reversed scan direction is indicated along the X-axis of the Scan Graph as well as in the left column of the Data Table.

In order to revert back to conventional scanning (low to high) you simply enter a positive Increment value, left-double-click the Increment control one more time, or chose *Reverse Scan Direction => Scan Low to High* from the context menu.

### Setting Time Format when performing time-dependent measurements

When setting up a Relative Time scan the Increment and Stop control values may be displayed and edited in a number of different time formats, such as *Seconds* or *Days:Hours:Minutes:Seconds* (i.e, structured time value format). You select the desired format via the context menu for the Stop control. The context menu is displayed by right-clicking the Stop control.

If you select the time format *Seconds*, any acquired data is referenced to a relative time value in seconds (when viewed in the Data Table or the Scan Graph, and when saved to file), regardless of how large the Stop control value might be.

If you select any of the structured time value formats, the time reference data format in the Data Table and the Scan Graph is automatically adjusted to the optimum structured format, while the format in a data file is fixed to be either *Hours:Minutes:Seconds* or *Hours:Minutes:Seconds.Milliseconds*, regardless of how many days might be involved.

The Data Table and the Scan Graph will show structured time values up to 72 hours as *Hours:Minutes:Seconds* and time values longer than 72 hours as *Days:Hours:Minutes:Seconds*.

#### 6.2.3.4 Scan Data Files

In Run Mode [6-20](#) *Scan*, the acquired data is recorded in a space-delimited ASCII file with a single text header line labeling the various data columns. In a scan data file, the left-most column contains the scan control data (e.g., frequency value when scanning the operating frequency), which is followed by the columns comprising all the data belonging to each scan *point*. That means, one row or line of a data file contains all the data associated with a single scan point. Depending on the configured Acquisition Options [6-23](#), a RAM-5000-SNAP data file can contain many columns of data. Yet additional columns could comprise the respective

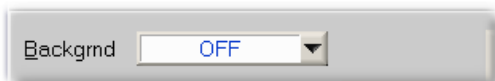
standard deviation data [3-13](#), as well as certain measurement data [8-2](#).

In the default setting of the user interface option **Prompt for filename at start of scan**, each time a new scan is initiated, a file browser dialog is launched, prompting you to specify a filename. This means, a *user-named* data file is created at the start of a scan. The filename will then be shown during the scan in the filename indicator, located at the top of the data acquisition control panel. When the scan finishes, this file is automatically closed.

If you choose to disable (see User Interface Preferences [3-12](#)) the automatically launched file browser dialog at the beginning of each scan, the scan will commence as soon as the START button is pushed. For increased data robustness, the data is still saved to temporary backup file(s) while a scan is in progress. Once finished, the button next to the filename indicator updates its label and becomes active. This may then be used to manually launch the file browser dialog, to save the newly acquired data. Otherwise, you are first asked whether to discard or save the *unsaved* scan data when a new scan is initiated, or when the instrument setup has changed and no longer reflects the system configuration with which the data was acquired. Once the data are saved to a *user-named* file, the backup file(s) are automatically deleted. As long as no new scan has been performed, the backup file(s) (lastScan.\*), will remain intact and may be found in the program folder of the RAM-5000-SNAP software installation, even after exiting and restarting the user interface.

## 6.2.4 Background

The control labeled "Backgrnd" is for setting whether or not background integrator data is automatically subtracted from signal integrator data at run time. In addition, if this control is set to any other setting than **OFF**, it also determines the acquisition mode of the background data. Collectively, this is referred to as the *Background Mode* setting.



If the Background Mode is set to **OFF**, no background data subtraction is being performed during data acquisition. Any background data that may be present is simply ignored, but not discarded. This allows for switching back and forth between making measurements with or without background subtraction.



Setting the Background Mode is set to **Pre-Run**, a square LED as well as a button labeled "Acquire" become visible. The color of the LED indicates the integrity status of background in memory. Hovering the mouse pointer over this LED when its color is either *green* or *yellow*, produces a temporary tip window listing various properties of the current background data. A *black* LED means either no background data is present, or the background has become invalidated. In this state, you will not be able to perform data acquisition until a valid background is restored (*or Background is turned OFF*). To acquire background at any time,

you may press the Acquire button next to the LED, which launches a dialog for setting up and acquiring background data. You may also wait until prompted when attempting to initiate normal data acquisition, which will automatically launch the Background Setup <sup>6-17</sup> dialog.

When deemed necessary by the user interface, it will execute a validation procedure on background data that is residing in memory. If it is determined that this data is usable and valid with respect to a series of settings pertaining to the current instrument and data acquisition configuration, the LED will light up *green*. If the data is found to be only "structurally" compatible, that is, in terms of such parameters like number of scan points or number of defined signal settings, the LED will light up *yellow*. In any other case, the LED will remain *black*.

To be safe, you should always try to use background data that has been fully validated, that is, to perform signal data acquisition with the background integrity status LED lit up *green* whenever possible. However, the case of only partially validated background data (LED is lit up *yellow*) is available to allow *you* to decide what to do. The algorithm that validates background may in a few cases prove to be too strict and then needlessly deem the data no longer fully valid. Then it is up to your discretion to ignore this status and continue using the background, or to acquire new one. The background handling procedures that are implemented in the RAM-5000-SNAP User Interface attempt to balance the need for a robust and safe methodology for taking background into account, while still allowing for a maximum amount of flexibility.

Since the Run Mode <sup>6-20</sup> **Scan** requires "structurally" different background data from any of the interactive data acquisition run modes, the user interface maintains two separate data buffers for the background. When changing the run mode, the software checks to see if background data is already present for the new run mode, and if so, immediately performs a series of validation tests and updates the background data integrity status LED accordingly. Although the user interface maintains separate data buffers, all run modes share the same Background Mode setting at any given time. It is not possible to change the Background Mode for only a specific run mode.



With the **Advanced Edition** of the RAM-5000-SNAP User Interface, two additional Background Modes are available. In the first, labeled **Run-Time**, background is acquired dynamically at run-time. This means, prior to each normal data acquisition *cycle*, the user interface automatically engages the background acquisition setup instrument configuration, acquires all necessary background data for this measurement point, and then re-engages the original instrument configuration to perform the actual signal acquisition. Since in this mode the background is valid essentially by default, the status LED is always lit up *green*, however dimmed. Next to the LED, the button will read "Setup", as it is used to launch the Background Setup dialog for the mere purpose of setting up *how* background is to be acquired at run-time. Although, this Background Mode is highly automated and might appear to be your first choice at all times, it is only applicable if the available background acquisition setup options are usable in conjunction with the given experimental setup. For example, if it is necessary to modify some of the experimental setup cabling during background acquisition, this mode may not be usable. In many cases it is not necessary to reacquire background constantly, which



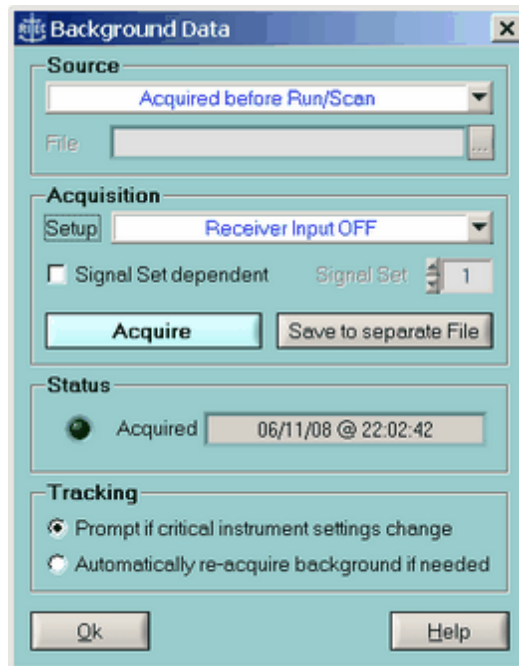
doubles the number of required integrator readings and thus doubles the measurement time. A case, for which this mode may be ideally suited is a time scan or similar relative measurement scenario which would extend over a sufficiently long time during which the background may change.



The second additional Background Mode, which is available with the **Advanced Edition** of the RAM-5000-SNAP User Interface, is labeled **On-File**. In this mode, background is also subtracted at run-time, however, not acquired but rather loaded from a background data file at some time earlier. With the exception of *how* the data got into the appropriate background buffer of the user interface, this mode is otherwise identical to the **Pre-Run** mode. The status LED functions identically, but the button next to it is labeled "Load", as the launched Background Setup panel is primarily used to load background data from a user-selected file.

### 6.2.4.1 Background Setup

On the Background Data panel you may set up each of the available Background Modes, with the exception of disabling background subtraction. *To disable, or turn off, run-time background correction, you must first close this panel and select **OFF** on the Background control located on the Data Acquisition Control Panel.* The **Source** frame determines the Background Mode and enables and disables various other controls on this panel accordingly.



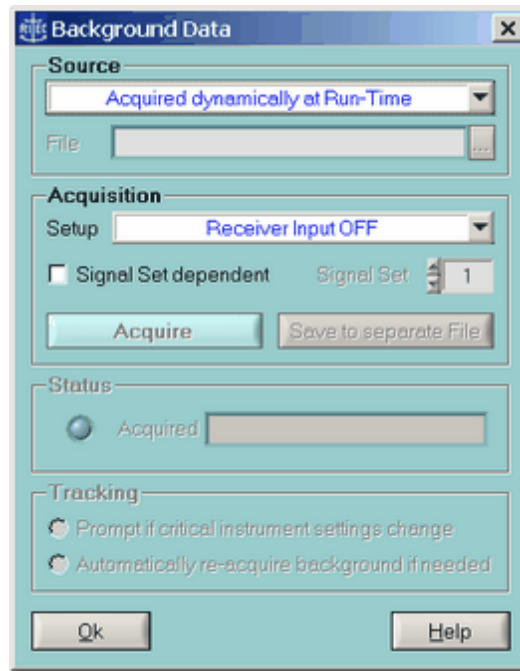
The Background Data dialog in 'Pre-Run' mode.

If the data *Source* control is set to **Acquired before Run/Scan**, which corresponds to Background Mode **Pre-Run**, you must first verify the *Setup* controls, located inside the **Acquisition** frame. The available acquisition setup options include **Same Receiver Channel**, **Alternate Receiver Channel**, and **Receiver Input OFF**. As these labels imply, setting up background acquisition simply means choosing a particular receiver input option. However, if multiple signal settings <sup>6-29</sup> are defined, you can also make the background setup a "set-to-set variable" by checking the option labeled **Signal Set dependent**. Now, each signal setting may be associated independently with one of the three acquisition setup options. Finally, you may proceed to acquire new background for the currently set run mode via the button labeled "Acquire". Once background data has been successfully acquired, the button labeled **Save to separate File** becomes enabled (**Advanced Edition only**), and allows this data to be saved to a custom background file for later reloading. Also, the status LED and the background time stamp info, both located inside the **Status** frame, will be updated to reflect the new data integrity status. Before you proceed to closing the Background Data panel, either none, or one of the **Tracking** options may be specified. Disabling both tracking options results in no action (other than updating the status LED) whenever the background validation algorithm detects a problem. Using this setting, you may ignore all warnings, dialogs, or re-acquisition attempts by the user interface should any occur. Selecting the tracking option **Prompt if critical instrument settings change** causes a dialog to be shown whenever the background validation algorithm detects a problem. In general, this dialog will offer three choices "Re-acquire background", "Ignore", or "Disable background correction", which among other things provides you with the opportunity to temporarily modify the experimental setup (if needed) before re-acquiring background on-the-fly. **Advanced Edition:** Selecting the second tracking option, **Automatically re-acquire background if needed**, causes no dialog to be shown when the background validation algorithm detects a problem. Instead, the background data is automatically re-acquired, followed by resuming normal data acquisition without any pause.

Each time background data is acquired via the **Acquire** button, the data is automatically saved to a file, named 'lastBackgrndXX.bid', where XX either reads SP (Single-Point) in the case of interactive DAQ, or MP (Multi-Point) with Run Mode *Scan*. The file extension BID stands for Background Integrator Data.

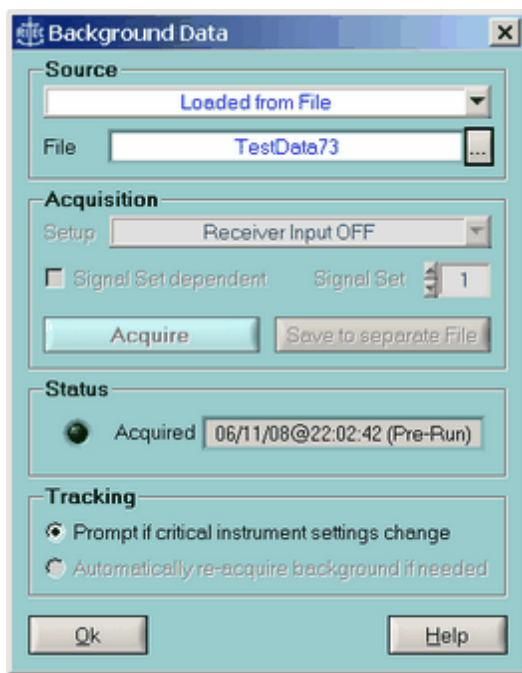
During any type of scan, the background data in memory is automatically saved into a file with the same name as the scan data file (\*.dat), but with the **.bid** extension. This way, you will always have a record of the background data being used with each scan. **Advanced Edition:** If a set of scan data is reloaded, and a file with the same name but the **.bid** extension is also present, it too is automatically reloaded.

**Advanced Edition:** If the data source control is set to **Acquired dynamically at Run-Time**, which corresponds to Background Mode **Run-Time**, only the acquisition *setup* option controls are enabled, as none of the others are applicable in this mode.



The Background Data dialog in 'Run-Time' mode.

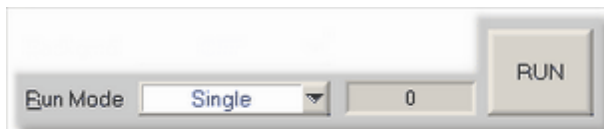
**Advanced Edition:** If the data source control is set to **Loaded From File**, which corresponds to Background Mode **On-File**, only the file browser control and the tracking option **Prompt if critical instrument settings change** are enabled. Once background data has been successfully reloaded, the dimmed acquisition *setup* controls will reflect the *original setup* used. Also, the status LED and the background time stamp info, both located inside the **Status** frame, will be updated to reflect the new data integrity status.



The Background Data dialog in 'On-File' mode.

**Advanced Edition:** Once scanned background data resides in memory, a new button on the scan panel (above the graph, to the right of the data view controls) will become available, and permit viewing of the data, even without having performed an actual scan. The button is only visible, if either of the *Integrator* data is selected for viewing. Pressing the button labeled **Backgrnd** allows you to either inspect the background-corrected integrator data or the background integrator data itself.

### 6.2.5 Run Mode



Acquisition Run Controls

The Run Mode control determines the method of acquisition, that is, how complete data acquisition *cycles* are executed (see Data Acquisition Overview [6-3](#) for more information on what comprises a data acquisition cycle).

Located next to the Run Mode control are the Burst Counter [6-2](#) and the acquisition RUN/START [6-2](#) button. The RAM-5000-SNAP User Interface provides up to four distinct run modes:

**Single** executes a single acquisition *cycle* and subsequently updates the display of the

chosen data view. You may then want to change any of the instrument settings, such as operating frequency, or some other experimental setup parameter. Eventually, you initiate (via RUN button) a new acquisition *cycle*, to obtain new data readings. This mode is for performing measurements one at a time, and may also be called the **Manual** run mode. In this mode you have full control over when and how data acquisition is performed, which may be especially useful if using extreme settings, such as a high gated amplifier output.

**Auto** is similar to Single in that it executes one full acquisition *cycle* at a time and subsequently updates the display of the chosen data view. Unlike in the Single run mode, each acquisition *cycle* is automatically *triggered* when you change any of the instrument settings. You never have to manually initiate acquisition to obtain new data. For example, this mode is quite practical and convenient when working with a delicate experimental setup as a minimum of bursts are triggered while keeping the data displays updated, or, to perform semi-automatic custom scanning by manually stepping through a range of instrument settings. The RUN button is disabled in this mode. *This run mode is only available with the Advanced Edition of the RAM-5000-SNAP User Interface.*

**Continuous** repeatedly executes a full acquisition *cycle* and subsequently updates the display of the chosen data view. Once data acquisition is initiated by clicking the RUN button, it will keep running until you cancel acquisition by clicking the STOP button. Each acquisition *cycle* is automatically *triggered* regardless of changes to the instrument setup.

**Scan** repeatedly executes a full acquisition *cycle* for a pre-defined range of instrument settings, which is initiated via the START button. While a scan is in progress, all instrument settings are under control of the selected scan type [6-8]. However, you may cancel the scan at any time via the STOP button, or switch to any of the interactive data display panels without switching the run mode. In addition, the scan data graph is updated at run-time, and you may change various data view properties, for example, invoke Auto-Scaling of either graph axis, at run-time.

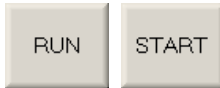
Switching from one of the three interactive acquisition modes to the **Scan** mode, automatically activate the *Scanning* [6-8] tab on the Acquisition Control Panel [6-3] as well as the *Scan* [7-14] tab among the various data display tabs. If you switch *from* the **Scan** mode to any of the other run modes, the last used Data Display (gauge or graph) is automatically activated. You may also indirectly change the run mode by simply selecting any one of the available data displays. The user interface automatically selects the appropriate run mode. One exception is the *Table* [7-12], since it may be used to view data in either run mode.

### 6.2.5.1 Burst Counter

The Burst Counter 137 shows the running burst or trigger count since last reset. A reset of this count will be invoked by the user interface whenever the Run Mode [6-20] is changed, or when acquiring Background Data [6-17]. This burst count may also be reset manually at any time by right-clicking the mouse pointer over the counter readout and selecting **Reset Burst Counter** from the context menu. Each burst event that is registered by this counter, is associated with a single data reading event of either pair of the integrator A/D channels (i.e., 0/90 or 180/270) or one auxiliary A/D channel (if enabled).

### 6.2.5.2 RUN/START

This button is the primary control for beginning and ending data acquisition in accordance with the selected Run Mode [6-20](#).



Depending on the run mode, the button label initially either reads RUN or START (when scanning).



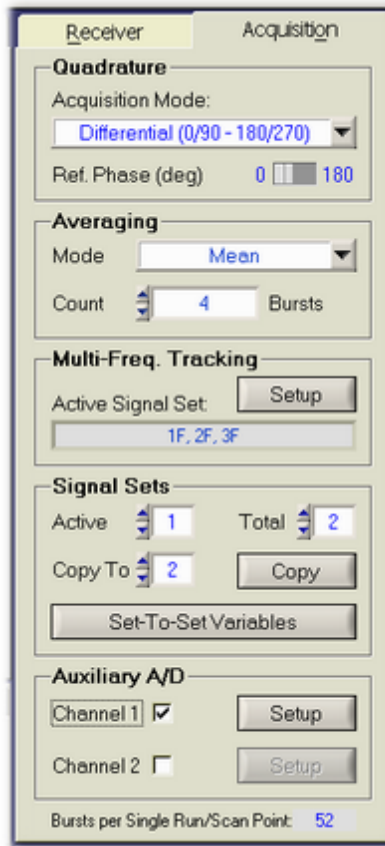
Once any data acquisition is in progress, the button label changes to STOP, and allows you to cancel acquisition.



This button is disabled if using run mode Run Mode *Auto*, as it is managed by the RAM-5000-SNAP User Interface.

You can also use the keyboard shortcut **F9** to start and stop acquisition.

### 6.3 Acquisition Options



The Acquisition options tab.

The Acquisition tab is for setting various data acquisition options. For example, on the Acquisition tab you may set up signal averaging, manage multiple signal acquisition settings, and enable DC signal data acquisition via two auxiliary A/D channels.

The Acquisition tab contains numerous controls which are grouped into five decorative and labeled frames. Their top-down placement on the tab reflects the sequence of acquisition control and processing steps that make up a so-termed *acquisition cycle*. This kind of a cycle is completed, for example, each time the RAM-5000-SNAP User Interface executes a Single Run [6-20] or processes one Scan Point [6-8]. The number of triggers (each transmitting a possibly unique burst signal, which is subsequently received, analyzed, and processed) required per one acquisition cycle is determined entirely by the options set on the Acquisition tab. To aid you when configuring data acquisition, the total number of "Bursts per Single Run/

Bursts per Single Run/Scan Point: 190

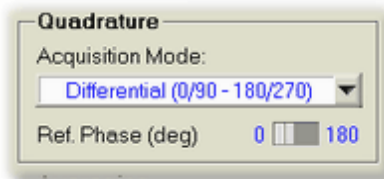
Scan Point" is displayed at the very bottom of the tab.

Each group of acquisition options is described in detail below:

- Quadrature Settings [6-24]
- Signal Averaging [6-25]

- Multi-Frequency Tracking [6-27](#)
- Multiple Signal Sets [6-29](#)
- Auxiliary A/D Channels [6-31](#)

### 6.3.1 Quadrature



*Quadrature Controls*

The Quadrature settings determine how the phase-sensitive detection is to be performed. You can control the Acquisition Mode and the Reference Phase.

#### 6.3.1.1 Acquisition Mode

The Acquisition Mode setting determines the phase detectors signal processing when performing data acquisition.

In the **Standard** Quadrature Acquisition Mode, a single burst is transmitted and then analyzed at 0/90° (or 180/270°, depending on the Reference Phase [6-24](#) setting), to obtain the *In-phase* and the *Quadrature* signal components.

If the Quadrature Acquisition Mode is set to **Differential**, two bursts are transmitted and analyzed at opposite phases, and the differences are used to arrive at the *In-phase* and the *Quadrature* signal components. If the first transmitted burst is analyzed at 0/90°, the second is analyzed at 180/270°. The Reference Phase setting determines which pair of phases is applied first. For more information, see Reduction of Measurement Errors [10-7](#) in the section Theory of Operation [10-2](#).

**Note:** When using the **Standard** Quadrature Acquisition Mode, please note the following. Dependent upon the type of measurement(s) you want to perform, it may be necessary to employ background data correction [6-15](#) in order to reduce measurement errors that would otherwise be common-mode-rejected when using the **Differential** Quadrature Acquisition Mode.

#### 6.3.1.2 Reference Phase

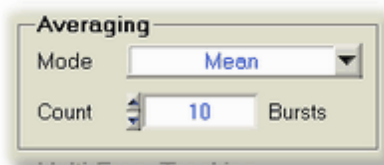
This control is for setting the phase reference of the *In-phase* phase detector to either 0 or 180 degrees. Selecting 0 degrees, automatically sets the phase reference of the *Quadrature* phase detector to 90 degrees, and selecting 180 degrees, automatically sets the *Quadrature* phase detector reference to 270 degrees.



**Note:** The two possible phase reference settings of either phase detector represent relative values with respect to the Detector Phase [\[ 5-7\]](#) control setting. That is, the phase references of both phase detectors are always offset by the LO phase setting of the super-heterodyne detector. For example, if the Detector Phase is set to 5 degrees, the *In-phase* phase detector would actually be detecting at 5 or 185 degrees, and the *Quadrature* phase detector would be detecting at 95 or 275 degrees, respectively.

The Reference Phase control is useful in determining if the phase-sensitive detectors are operating properly. When observing the output of one of the phase detectors (see Rear Panel Instrument Connectors [\[ 11-4\]](#)), the polarity of the signals should change when this toggle switch is activated. The value set in this control affects the actual measurement, when operating in the **Standard** (single-pulse) Quadrature Acquisition Mode [\[ 6-24\]](#).

### 6.3.2 Averaging



*Averaging Controls*

The RAM-5000-SNAP User Interface offers two modes of signal averaging, Mean and Weighted Running. Averaging is optional and may also be disabled by choosing the Mode control setting *OFF*.

#### 6.3.2.1 Mean Average

This is the standard averaging mode within the RAM-5000-SNAP User Interface, and is available in all data acquisition Run Modes [\[ 6-20\]](#). Mean averaging provides a good signal-to-noise ratio improvement capability, however, at the expense of response time. The data calculated and displayed is the arithmetic mean value of  $N_{AVE}$  successive integrator readings,  $V_i$ , as defined by

$$\bar{V} = \frac{V_1 + V_2 + \dots + V_{N_{AVE}}}{N_{AVE}} = \frac{1}{N_{AVE}} \sum_{i=1}^{N_{AVE}} V_i$$

The numeric control below the *Mode* control is for setting the averaging count,  $N_{AVE}$ .

### 6.3.2.2 Weighted Running Average

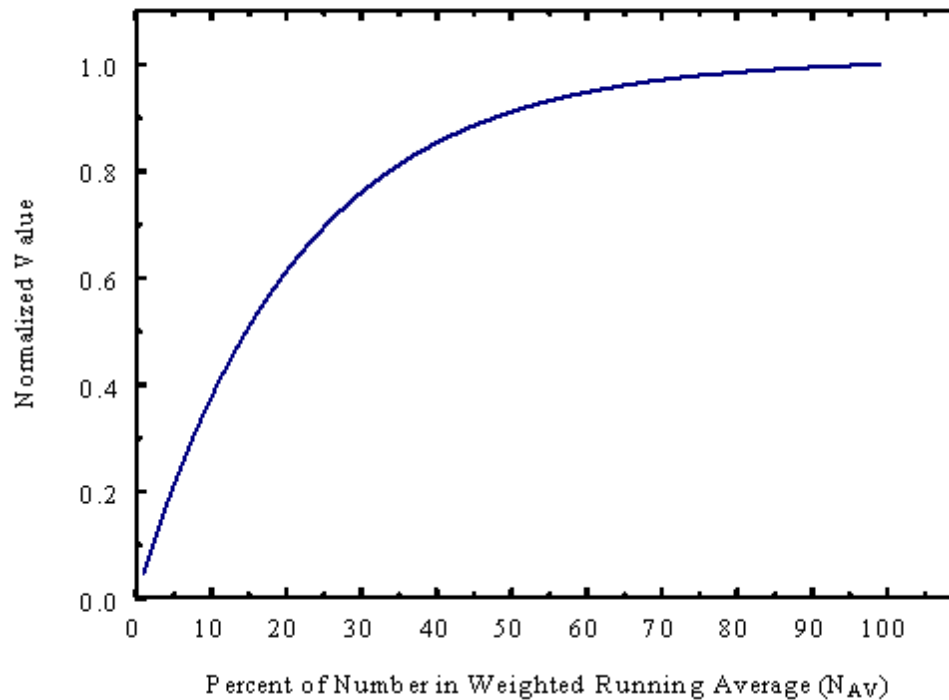
*Advanced Edition only*

The Weighted Running Average mode attempts to optimize both signal-to-noise ratio and quick response to a changing signal, and is available in the *Continuous* data acquisition Run Mode [\(6-20\)](#). The data calculated and displayed is a weighted average of the last  $N_{AVE}$  integrator readings,  $V_i$ , defined by

$$\bar{V}_i = \frac{V_i + f V_{i-1} + f^2 V_{i-2} \dots + f^{(N_{AVE}-1)} V_{i-N_{AVE}}}{(1 + f + f^2 \dots + f^{(N_{AVE}-1)})}$$

The weighting factor,  $f$ , used is chosen such that, if  $N_{AVE}$  is 100, the oldest term included in the averaging has only 1/100 the weight of the most recent reading, that is,

$$f^{(N_{AVE}-1)} = \frac{1}{N_{AVE}}$$

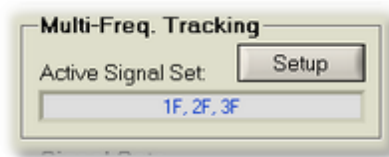


*Response of Weighted Running Average to a Step Function.*

The numeric control below the *Mode* control is for setting the averaging count,  $N_{AVE}$ .

### 6.3.3 Multi-Frequency Tracking

*Advanced Edition only*



*Multi-Frequency Tracking Controls*

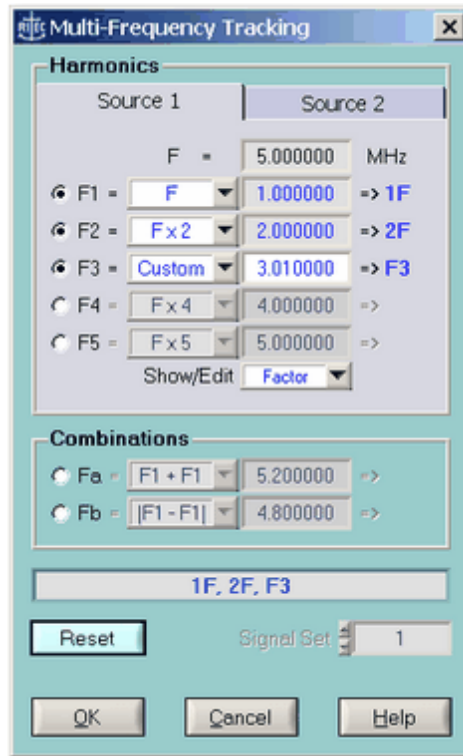
Multi-Frequency Tracking allows you to define multiple receiver tracking frequencies within a single signal set [6-29](#). In addition, unlike with standard receiver tracking [5-5](#), Multi-Frequency Tracking also allows you to define custom tracking frequency.

The text box below the label **Multi-Freq Tracking:** is for showing the current MFT setup as defined for the active signal set.

The Setup [6-28](#) button opens the dialog for defining advanced multi-frequency receiver tracking options.

### 6.3.3.1 MFT Setup

*Advanced Edition only*



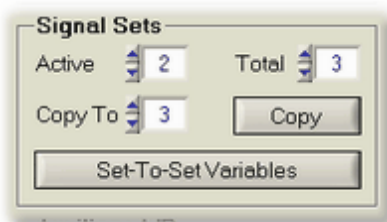
*The Multi-Frequency Tracking setup dialog.*

The Multi-Frequency Tracking setup dialog allows you to define up to 6 different receiver tracking frequencies for each signal set. These tracking frequencies may be based on conventional harmonic theory, that is a second harmonic would be tracked at exactly two times the fundamental frequency. Or, a tracking frequency may also be based on a customized frequency factor. For example, a particular frequency might track a fundamental at a factor of 1.95 instead of exactly 2. Moreover, sub-harmonics or any type of combination frequency (sums and differences) may also be easily set up.

**Note:** Even if certain tracking options on the Multi-Frequency Tracking setup dialog can not be realized due to an instrument's bandwidth limitations, setting up Multi-Frequency Tracking data acquisition configuration can still be very useful for certain experimental scenarios. For example, enabling and setting each of the "xF =" or "Fx =" tracking options to *Custom* you could acquire data (automatically) at up to seven additional, arbitrarily chosen, detector frequencies without the need for an auxiliary detector frequency scan. And, if the source frequency is changed, each of the custom tracking frequencies will track the source frequency according to the frequency ratio associated with each custom setting. (Other tracking options may be implemented in addition upon request.)

### 6.3.4 Signal Sets

An entire instrument setup may be collectively described as a signal setup, because you typically optimize the instrument setup with respect to a particular signal that is to be analyzed. The term "signal setup" may also be labeled "signal set", or short "signal". Usually, analyzing a single signal provides a rather limited amount of information. Scanning a particular instrument setting, such as burst frequency, would be the next step toward obtaining more meaningful information from a given experimental setup. Often, however, scanning is either not feasible or simply not sufficient. Instead, what is needed is a capability to analyze a certain signal using multiple defined *parallel* signal sets, or instrument setups, such that when making a single measurement multiple related pieces of data can be obtained simultaneously. As an example, in a typical nonlinear acoustic measurement, it is usually not enough to acquire only the fundamental frequency signal magnitude, or to acquire only the second harmonic signal magnitude, but both magnitude values are needed, as the ratio of both values tends to be much more informative. This specific need is addressed by the ability to define multiple receiver tracking frequencies [6-27](#) within a single signal set. To set up multiple tracking frequencies is equivalent to setting up multiple signals, each being limited to a different tracking frequency. The RAM-5000-SNAP User Interface allows for multiple signal sets that differ from one another by much more than just a tracking frequency. Instead, each individual signal set comprises a complete instrument setup.



Signal Sets Controls

The following controls, which are all located within the **Signal Sets** frame, aid in the management of multiple signals:

**Active** sets the active signal. This control is linked with the control labeled **Active Signal Set** [6-31](#), which is located below the Receiver and Acquisition tabs, where it is visible at all times. Changing the active signal updates all instrument controls as well as various Data Displays with the acquired data for this signal.

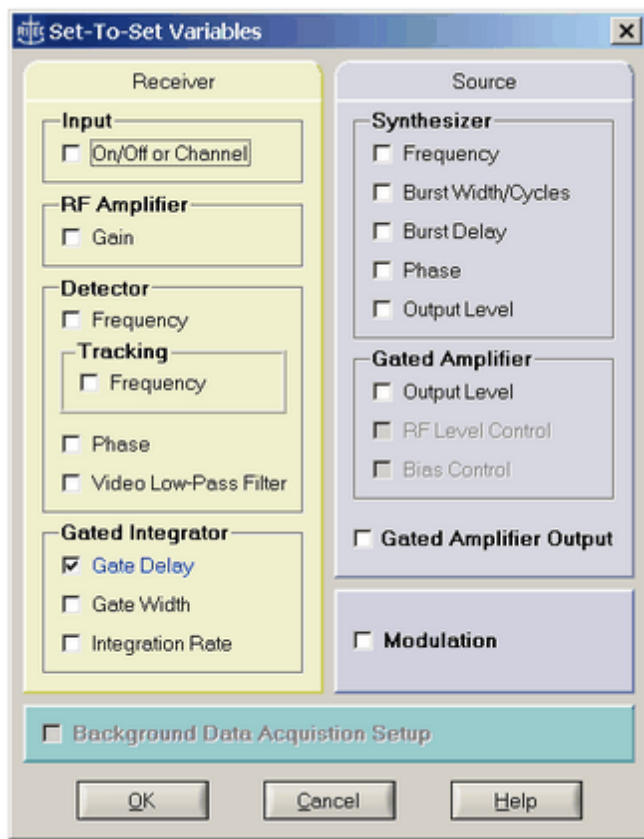
**Total** sets the total number of *defined* signals. The standard limit is 2. With the **Advanced Edition**, this number may be as high as 6. When increasing the number of signals, the user interface automatically initializes each additional signal set based on the currently active one.

**Copy To** sets the target signal for copying between sets.

**Copy** copies the currently active signal set to the one selected in **Copy To**.

**Set-To-Set Variables** opens the Set-To-Set Variables [6-30](#) dialog, which provides an overview of all instrument settings that may be made a variable between signals. The dialog also provides access to all of these variables at the same time.

### 6.3.4.1 Set-To-Set Variables



The Set-To-Set Variables setup dialog.

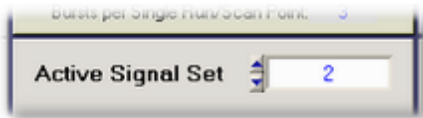
The Set-To-Set Variables setup dialog provides an overview of all instrument settings that may be made a variable between signals. This dialog also provides convenient access to all these variables at once.

An instrument setting that is not selected, is locked across signal sets. For example, changing the burst frequency in signal set 1, will automatically update the burst frequency in all other defined signal sets. Selecting an instrument setting unlocks it and may then be configured independently in any of the *defined* signal sets. In general, all set-to-set variables (instrument settings) should be deselected, except for the ones specifically wanted. A customized set-to-set variables scheme is ignored, but not discarded, if you decide to limit the number of signal sets to 1. Restoring multiple signal sets automatically restores the previous set-to-set variables scheme, but not necessarily the individual instrument control settings.

Each particular set-to-set variable (instrument setting) may also be accessed and modified, that is locked or unlocked, from the context menu associated with each instrument control. For example, suppose **Source Frequency** is currently locked across multiple defined signal sets. Right-clicking the mouse pointer over the frequency control on a source panel produces a context menu which includes the item **Make Set-To-Set Variable**. *Selecting this item has*

the same effect as opening the Set-To-Set Variables Setup dialog and selecting the item **Source Frequency**. Once the **Source Frequency** is unlocked, the label of the frequency control on the source panel will be **blue** instead of *black*. A *blue* control label indicates that the associated control is unlocked across multiple signal sets. Right-clicking the mouse pointer over the frequency control produces a context menu which includes the item **Undo Set-To-Set Variable**.

### 6.3.4.2 Active Signal Set

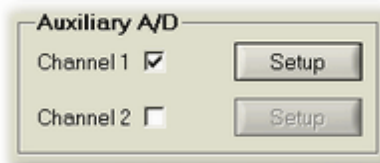


This control is located below the Receiver and Acquisition tabs, where it is always visible. It allows you to set the active instrument and analog signal processing configuration, when using multiple Signal Sets [6-29]. Changing the active signal automatically reprograms all those instrument settings that are different from the previous signal set, that is, the so called Set-To-Set Variables [6-30], and updates the respective instrument control values on the user interface. If data was already acquired for the selected signal and resides in computer memory, various Data Displays [7-2] may also be updated.

### 6.3.5 Auxiliary A/D Channels

Two Auxiliary A/D channels, labeled "External Sensor" on the rear panel of the RAM-5000-SNAP, can be used to input the output of a variety of measurement devices, which may need to be monitored during an experiment. For example, such a signal might come from a thermocouple to measure temperature, the analog output of a temperature bridge, or a manometer to read the pressure.

Each 12-bit A/D converter has a nominal input range of -5 to +5 Volts DC. If the input cables are left open without an impedance of less than 2000 Ohms between the positive input and ground, or if the cables are disconnected, the inputs will float high to approximately 1.77 Volt.



Auxiliary A/D Channel Controls

To enable acquisition on either A/D channel, check mark the appropriate box labeled "Channel 1" or "Channel 2". Enabling or disabling either of these channels may only be done while data acquisition is inactive. Once enabled, each of the available Data Displays [7-2] contains one additional Data Type [7-1] item per channel. Auxiliary A/D data are acquired always at the end of a complete integrator data acquisition cycle, and may be viewed at run-

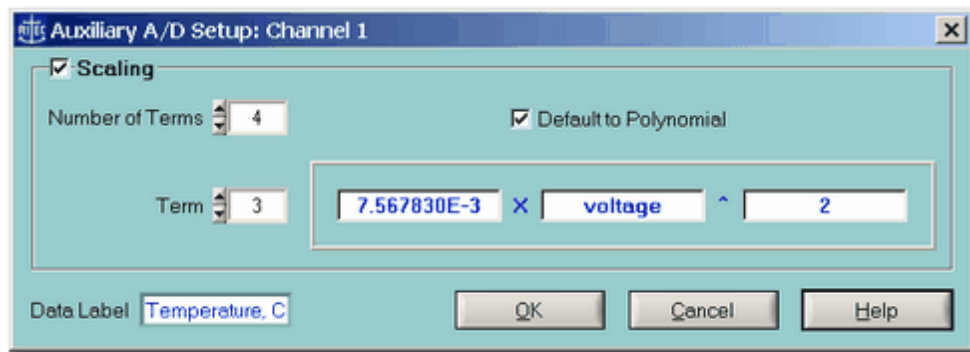
time just like any other RAM-5000-SNAP data. In addition, the auxiliary A/D data is automatically stored in the same file as integrator-based data. A single auxiliary A/D data read event requires a burst trigger.

**Note:** At present, data acquired via auxiliary input *Channel 1* may be viewed only through *Channel A*, and auxiliary input *Channel 2* data may be viewed only through *Channel B* of the various meters (Analog and Digital Gauges) and graphs (Strip Charts and AB Graph).

**Advanced Edition:** To independently set up data scaling on either A/D channel, or to assign a custom data label, press the Setup<sup>6-32</sup> button next to the appropriate channel enable control.

### 6.3.5.1 Auxiliary A/D Setup

*Advanced Edition only*



*The Auxiliary A/D Setup dialog.*

The Auxiliary A/D Setup dialog may be used to set up data scaling on the selected A/D channel, or to assign a custom data label, to be used in all Data Displays<sup>7-2</sup> as well as when storing the data in a file.

Customizing the display range of data coming from either auxiliary A/D channel, consists primarily of defining parameters that will automatically scale the input voltage. After check marking the box labeled **Scaling**, you may define up to a maximum of 10 independent algebraic terms, using the numeric control labeled **Number of Terms**. The minimum number of terms is 2. You may choose to set up a standard polynomial by check marking the box **Default to Polynomial**, or leave this box empty, in which case each term may use a different function. Either way, you then define each individual term by first selecting it via the numeric control labeled **Term**. Each term starts with a floating point value coefficient, which is either multiplied by the voltage to a selected power, or multiplied by the exponential of the voltage times a floating point value factor. By definition, the range of possible numeric power values is limited to integer values.

The scaling capability may be used to map the range of, for example, a particular thermocouple onto the dynamic range of the auxiliary A/D converter. As a result, the Data Displays of the RAM-5000-SNAP user interface might display a real temperature value rather



than some voltage. Even if only the voltage value is of interest, the scaling capability could still be used to improve the linearity of a particular A/D. This would be accomplished, by specifying the terms of fitted calibration data instead.

Finally, a text control is provided for assigning a custom label to the data acquired on the selected Auxiliary Input Channel. This data label will be used even if the run-time scaling is disabled.

# Section 7

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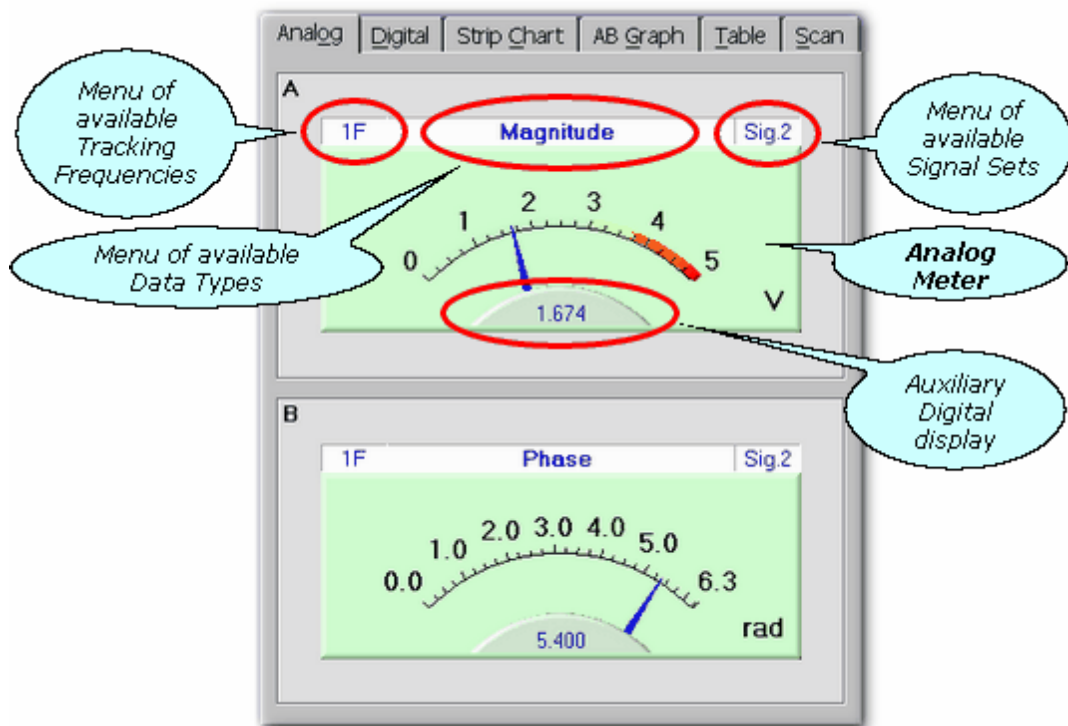
*Data Display*

## 7 Data Display

The RAM-5000-SNAP User Interface includes a number of different meters, graphs, and a table view, to display acquired data. These are organized onto individual tabs and are located above the Data Acquisition Control Panel [6-3](#).

- Analog Gauges [7-2](#)
- Digital Gauges [7-4](#)
- Strip Charts [7-6](#)
- A versus B Graph [7-9](#)
- Table View [7-12](#)
- Scan Graph [7-14](#)
- *Common Display Controls* [7-17](#)

### 7.1 Analog Gauges



The gauges on the Analog tab.



The *Analog* tab is for monitoring data acquisition via two large independent analog meters, one for each data display channel (A and B).

The following topics describe the various controls and components of the Analog tab:

- View Tracking Frequency [7-18](#) | Data Type [7-17](#) | Signal Set [7-18](#)

- The Analog Meter 
- Auxiliary Digital Display 


Below are descriptions of the popup menu options that are available when right-clicking the mouse pointer on the tab's label or anywhere else on the tab, except on a control or either meter area.

- Detach/ReAttach 'Analog Meters' 
- Help 





**Detach 'Analog Meters'** frees the Analog tab from the main window of the RAM-5000-SNAP user interface and makes the analog meters available on a separate, freely moving window. To confine the analog meters back to a tab on the main window, simply close the Analog window by clicking the [x] button on the right of the title bar, or select **ReAttach 'Analog Meters'** from the popup menu when right-clicking inside the window.

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the Analog tab/window.

### 7.1.1 The Analog Meter

This gauge is for monitoring data acquisition in an intuitive analog format. Near the bottom of each Analog Meter, there is a small Auxiliary Digital Meter  for displaying the same data also in a precise numeric format.

**Right-clicking** anywhere on the Analog Meter produces a popup menu with the following options:

- Zoom > Recenter 
- Zoom > Full Range 
- Zoom > x 2, 4, 10, ... 
- Help 

**Zoom > Recenter** resets the midpoint of the display range, based on the average of the 10 most recent data values.

**Zoom > Full Range** resets the dynamic range back to the maximum according to the selected Data View.

**Zoom > x 2,4,10...** zooms the dynamic range by the selected magnification. Once enabled, the midpoint of the display range is automatically reset (based on the average of the 10 most recent data values) if a data value falls outside of the current range.

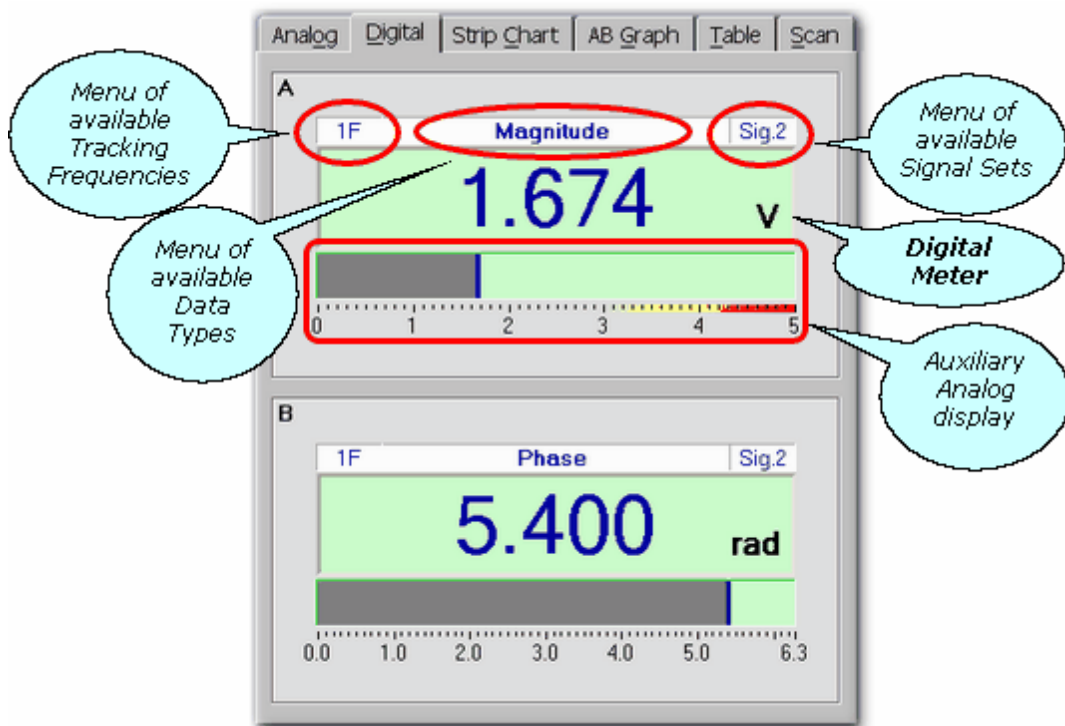
**Help** opens the RAM-5000-SNAP Help viewer with help specific to the Analog Meter.

### 7.1.2 Auxiliary Digital Display

This small digital display is for monitoring the same data, as selected for the Analog Meter [7-3] above it, also in a precise numeric format.

The Auxiliary Digital Display is linked to the Digital Meter [7-5] (located on the 'Digital' tab) of the same display channel (A or B) in terms of its display properties. **Right-clicking** the mouse pointer over the auxiliary readout produces a context popup menu with options such as display Precision [7-5].

## 7.2 Digital Gauges



The gauges on the Digital tab.

The *Digital* tab is for monitoring data acquisition via two large independent digital meters, one for each data display channel (A and B).

The following topics describe the various controls and components of the Digital tab:

- View Tracking Frequency [7-18] | Data Type [7-17] | Signal Set [7-18]
- The Digital Meter [7-5]
- Auxiliary Analog Display [7-5]

Below are descriptions of the popup menu options that are available when right-clicking the mouse pointer on the tab's label or anywhere else on the tab, except on a control or either


meter area.

- Detach/ReAttach 'Digital Meters' 
- Help 



**Detach 'Digital Meters'** frees the Digital tab from the main window of the RAM-5000-SNAP user interface and makes the digital meters available on a separate, freely moving window. To confine the digital meters back to a tab on the main window, simply close the Digital window by clicking the [x] button on the right of the title bar, or select **ReAttach 'Digital Meters'** from the popup menu when right-clicking inside the window.

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the Digital tab/window.

### 7.2.1 The Digital Meter

This gauge is for monitoring data acquisition in a precise digital format. Located below each Digital Meter, there is a complementary Auxiliary Analog Display  for showing the same data in an intuitive analog format in terms of a horizontal bar graph.


**Right-clicking** anywhere on the Digital Meter produces a popup menu with the following options:



- Precision > 0, 0.0, 0.00, ... 
- Help 

**Precision > 0, 0.0, 0.00, ...** changes display precision to the one selected from the available choices.

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the Digital Meter.

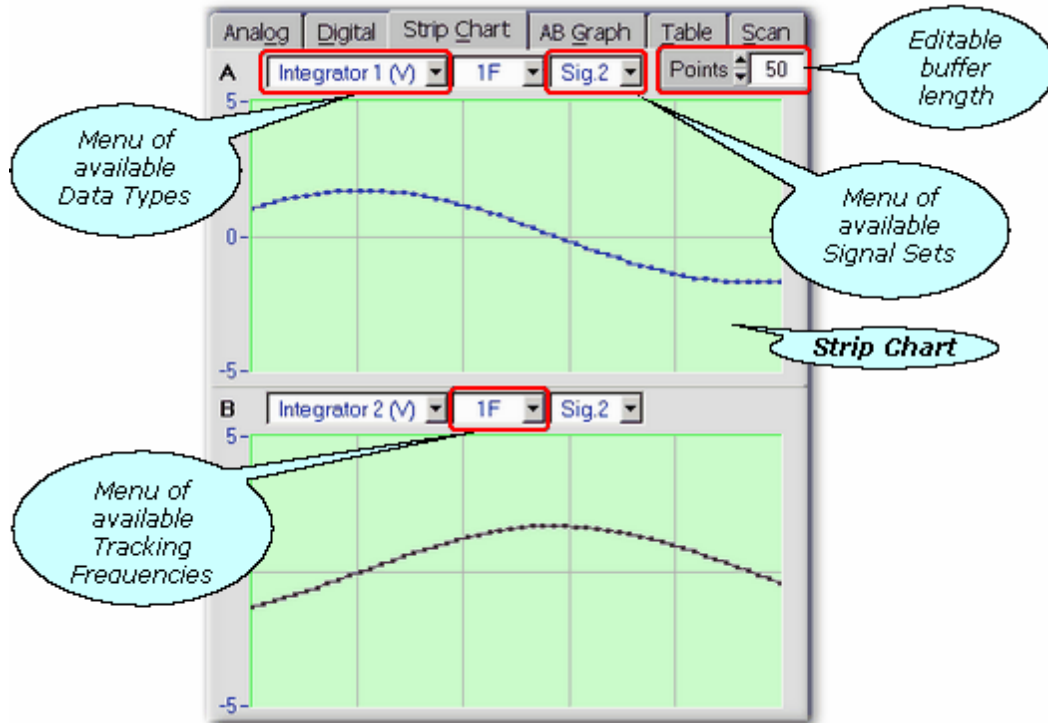
### 7.2.2 Auxiliary Analog Display

This meter is for monitoring the same data, as selected for the Digital Meter  above it, in an intuitive analog format.

The Auxiliary Analog Display is linked to the Analog Meter  (located on the 'Analog' tab) of the same display channel (A or B) in terms of its display properties. **Right-clicking** the mouse pointer over the auxiliary meter produces a context popup menu with options such as Zoom .

## 7.3 Strip Charts

*Advanced Edition only*



*The graphs on the Strip Chart tab.*

The *Strip Chart* tab is for monitoring data acquisition via two vertically (y-axis) independent but horizontally (x-axis) synchronized data history graphs, one for each data display channel (A and B). The relative size (vertically) of both charts may be adjusted by dragging the dividing line up or down using the mouse pointer.

The following topics describe the various controls and components of the Strip Chart tab:

- [View Data Type](#) | [Tracking Frequency](#) | [Signal Set](#)
- [View Number of Points](#)
- [The Strip Chart](#)

Below are descriptions of the popup menu options that are available when right-clicking the mouse pointer on the tab's label or anywhere else on the tab, except on a control or either strip chart area.

- [Detach/ReAttach 'Strip Charts'](#)
- [Help](#)

**Detach 'Strip Charts'** frees the Strip Chart tab from the main window of the RAM-5000-SNAP user interface and makes the strip charts available on a separate, freely moving and

sizable window. To confine the strip charts back to a tab on the main window, simply close the Strip Chart window by clicking the [x] button on the right of the title bar, or select **ReAttach 'Strip Charts'** from the popup menu when right-clicking inside the window.

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the Strip Chart tab/window.

### 7.3.1 Number of Points

This control is for setting the number of measurement points to be displayed in both **Strip Charts**. As the Number of Points are increased or decreased, the Strip Charts will be updated depending on how much data is already available in the time-history buffer.

**Note:** The Strip Charts, as well as the AB Graph [\[7-9\]](#) and the Data Table [\[7-12\]](#), share the same time-history buffer. The size of this buffer is determined by the largest Number of Points/Rows setting of all three data displays. If the Number of Points setting of the Strip Charts is increased to a value that is still less than or equal to the buffer size, more actual measurement data may be viewed without having to acquire additional data.

### 7.3.2 The Strip Chart

The strip chart is ideal for viewing the time-history of the acquired data. Each Strip Chart provides the capability to view as many data points as are presently available in the gauges data buffer (see Number of Points [\[7-7\]](#)). Several options are available to modify the strip chart display properties, including Y axis zoom magnifications with a floating midpoint.

**Right-clicking** the mouse pointer over either axis produces a context popup menu showing all options available for the selected axis. From the Y axis menu, you may also open a dialog box for editing additional Axis Properties [\[7-19\]](#).

**Right-clicking** anywhere on the data plot region produces a popup menu showing options for both axes.


Below are descriptions of the popup menu options that may be seen, depending on where on the strip chart you right-click the mouse pointer.

- X-Axis > Show Point Range [\[7-8\]](#)
- X,Y-Axis > Show Grid [\[7-8\]](#)
- Y-Axis > Zoom > Recenter [\[7-8\]](#)
- Y-Axis > Zoom > Full Range [\[7-8\]](#)
- Y-Axis > Zoom > x 2,4,10, ... [\[7-8\]](#)
- Y-Axis > Properties... [\[7-8\]](#)



- Help 

**X-Axis > Show Point Range** enables or disables the display of the running point count, more specifically the oldest and the most recent valid data points in the strip chart data buffer.

**X,Y-Axis > Show Grid** enables or disables the display of the **major grid** (and **minor grid** if enabled) for the respective axis. The *major* grid lines spacing may be set via the **Divisions** setting on the Axis Properties  dialog.

**Y-Axis > Zoom** submenu options provide an alternative method of a zoom.

**Y-Axis > Zoom > Recenter** resets the midpoint of the display range, based on the average of the 10 most recent data values.

**Y-Axis > Zoom > Full Range** resets the limits for the Y axis to the maximum dynamic range according to the selected Data View.

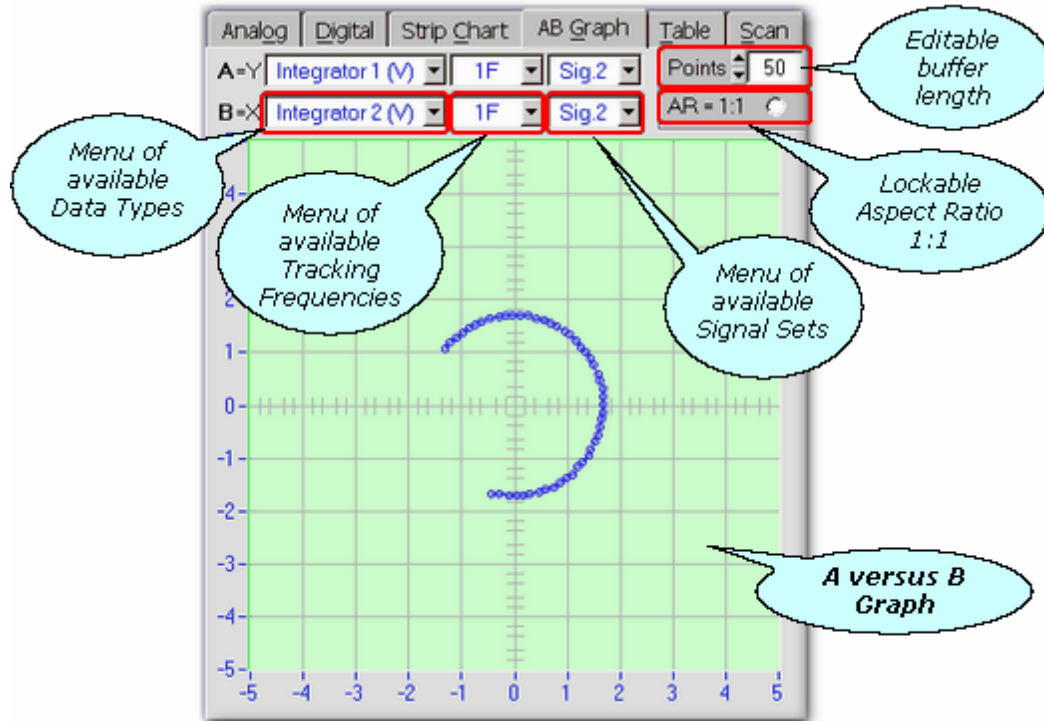
**Y-Axis > Zoom > x 2,4,10...** zooms the dynamic range by the selected magnification. Once enabled, the midpoint of the display range is automatically reset (based on the average of the 10 most recent data values) if a data value falls outside of the current range.

**Y-Axis > Properties...** opens a dialog box for setting additional Axis Properties .

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the Strip Chart.

## 7.4 A versus B Graph

Advanced Edition only



The A versus B graph on the AB Graph tab.

The *AB Graph* tab is for monitoring data acquisition via an XY graph in terms of a parametric plot. The data normally displayed through channel B are plotted against the data normally displayed through channel A in any of the other gauges.

The following topics describe the various controls and components of the AB Graph tab:

- Plot in **A=Y, B=X** Data Type [7-17](#) | Tracking Frequency [7-18](#) | Signal Set [7-18](#)
- Plot Number of Points [7-10](#)
- Lock Aspect Ratio 1:1 [7-10](#)
- The AB Graph [7-10](#)

Below are descriptions of the popup menu options that are available when right-clicking the mouse pointer on the tab's label or anywhere else on the tab, except on a control or the graph area.

- Detach/ReAttach 'AB Graph' [7-9](#)
- Help [7-10](#)

**Detach 'AB Graph'** frees the AB Graph tab from the main window of the RAM-5000-SNAP user interface and makes the A versus B graph available on a separate, freely moving and

sizable window. To confine the graph back to a tab on the main window, simply close the AB Graph window by clicking the [x] button on the right of the title bar, or select **ReAttach 'AB Graph'** from the popup menu when right-clicking inside the window.

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the AB Graph tab/window.

### 7.4.1 Number of Points

This control is for setting the number of measurement points to be displayed in the **A versus B Graph**. As the Number of Points are increased or decreased, the AB Graph will be updated depending on how much data is already available in the time-history buffer.

**Note:** The AB Graph, as well as the Strip Charts [7-6](#) and the Data Table [7-12](#), share the same time-history buffer. The size of this buffer is determined by the largest Number of Points/Rows setting of all three data displays. If the Number of Points setting of the AB Graph is increased to a value that is still less than or equal to the buffer size, more actual measurement data may be viewed without having to acquire additional data.

### 7.4.2 Aspect Ratio 1:1

This control is for setting the aspect ratio of the graph to one. This may be necessary and helpful if comparable data, e.g., Integrator 2 versus Integrator 1, are to be plotted against each other in order to better visualize certain characteristics, e.g., orthogonality between nominally 90° out-of-phase data.

### 7.4.3 The AB Graph

This gauge is for monitoring data acquisition on an XY graph. The data normally displayed through channel A are plotted against the data normally displayed through channel B in any of the gauges. The AB Graph provides the capability to view and further analyze as many data points as are presently available in the gauges data buffer (see Graph Points [7-10](#)). Several options are available to modify various graph and data plot properties, including interactive zooming. For example, you may zoom both axes simultaneously using the left mouse button by drawing an *imaginary* rectangle on the plot region while holding down the **Ctrl-key**. To undo the last zoom step, hold down the **Shift-key** and **left-click** anywhere on the graph.

**Left-double-clicking** the mouse pointer over either axis opens a dialog box with properties specific to the respective axis (see Axis Properties [7-19](#)).

**Right-clicking** the mouse pointer over either axis produces a context popup menu showing all options available for the selected axis. From this menu, you may also open a dialog box for editing additional Axis Properties [7-19](#) (*same as if left-double-clicking*).

**Right-clicking** anywhere on the data plot region produces a popup menu showing options for both axes. In addition, from this menu, you may open another dialog box for editing all Graph Properties [\[ 7-20 \]](#) at once, including various data plot properties.

Below are descriptions of the popup menu options that may be seen, depending on where on the graph you right-click the mouse pointer.

- X,Y-Axis > Auto Range [\[ 7-1 \]](#)
- X,Y-Axis > Zoom > Interactive [\[ 7-1 \]](#)
- X,Y-Axis > Zoom > Full Range [\[ 7-1 \]](#)
- X,Y-Axis > Show Grid [\[ 7-1 \]](#)
- X,Y-Axis > Log Scaling [\[ 7-1 \]](#)
- X,Y-Axis > Properties... [\[ 7-1 \]](#)
- Properties... [\[ 7-12 \]](#)
- Help [\[ 7-12 \]](#)

**X,Y-Axis > Auto Range** enables or disables auto *scaling* mode for the respective axis. In this mode, the visible axis range is automatically (and dynamically during data acquisition) adjusted to match the range between the smallest and the largest data values. Enabling this mode automatically invalidates all Zoom options and enables **Auto Divisions** for the respective axis. The **Divisions** setting may also be manually controlled from the Axis Properties [\[ 7-19 \]](#) dialog. Disabling this mode locks the present limit values of the respective axis.

**X,Y-Axis > Zoom > Interactive** enables or disables interactive zooming for the respective axis. Once enabled, the upper and lower limits of this axis may be adjusted interactively using the left mouse button by drawing an *imaginary* elongated rectangle on the plot region. The most recent zoom action may be undone by **left-clicking** anywhere on the graph while holding down the **Shift-key**. Each successful zoom action automatically disables zooming for the respective axis, so that no additional zooming may occur by accident. To perform additional interactive zooming, it must first be enabled. Enabling this mode automatically invalidates Auto Range and Zoom > Full Range. Disabling this mode (for example, if activated by accident) removes the zoom activation, but changes nothing else.

**X,Y-Axis > Zoom > Full Range** resets the limits for the respective axis to the maximum dynamic range according to the selected Data View. Invoking this action automatically invalidates Auto Range and Zoom > Interactive.

**X,Y-Axis > Show Grid** enables or disables the display of the **major grid** (and **minor grid** if activated) for the respective axis. The *major* grid lines spacing may be set via the **Divisions** setting on the Axis Properties [\[ 7-19 \]](#) dialog.

**X,Y-Axis > Log Scaling** enables or disables *logarithmic* data mapping for the respective axis. In this mode, the limit values of either axis are always rounded up or down to the nearest power of 10.

**X,Y-Axis > Properties...** opens a dialog box with properties specific to the respective axis

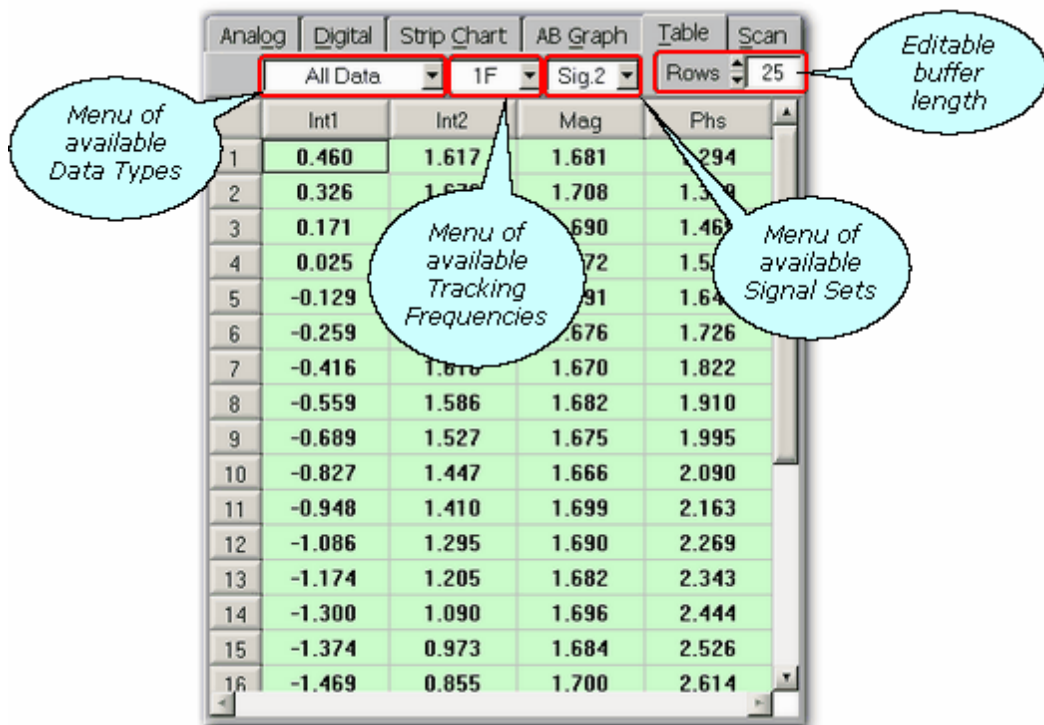
(see Axis Properties [7-19](#)).

**Properties...** opens a dialog box for editing all Graph Properties [7-20](#) at the same time, including various data plot properties.

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the AB Graph.

## 7.5 Table View

*Advanced Edition only*





The data matrix view on the Table tab.

The *Table* tab is for monitoring data acquisition (for display update rates  $\leq 1$  Hz) or for viewing already acquired data in table format. The data table serves two purposes. Depending on the Run Mode [6-20](#) last selected, the table displays either data from a buffer (similar to strip charts), or displays an entire set of scan data. In run modes *Single* through *Continuous*, the table will hold data from general data acquisition, whereas in the run mode *Scan*, the table will hold scan data. The last selected run mode does not necessarily have to have been actively acquiring data. As long as the general data buffer is not empty, or there are data still visible on the scan data graph, the table will automatically display either data depending on whether a gauge or the scan panel was last shown.

The following topics describe the various controls and components of the Table tab:

- [View Data Type](#) [7-17](#) | [Tracking Frequency](#) [7-18](#) | [Signal Set](#) [7-18](#)

- View Number of Rows 
- The Table 

Below are descriptions of the popup menu options that are available when right-clicking the mouse pointer on the tab's label or anywhere else on the tab, except on a control or the table area.

- Detach/ReAttach 'Data Table' 
- Help 



**Detach 'Data Table'** frees the Table tab from the main window of the RAM-5000-SNAP user interface and makes the data table available on a separate, freely moving and sizable window. To confine the table back to a tab on the main window, simply close the window by clicking the [x] button on the right of the title bar, or select **ReAttach 'Data Table'** from the popup menu when right-clicking inside the window.

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the Table tab/window.

### 7.5.1 Number of Rows

This control is for setting the number of measurement points to be displayed in the **Data Table**. As the Number of Rows are increased or decreased, the Table will be updated depending on how much data is already available in the time-history buffer.

If data from a scanned data acquisition is displayed in the Data Table, this control will be inactive, since in this case the number of rows are fixed and set by the number of scan points.

**Note:** The Data Table, as well as the Strip Charts  and the AB Graph , share the same time-history buffer. The size of this buffer is determined by the largest Number of Points/Rows setting of all three data displays. If the Number of Rows setting of the Data Table is increased to a value that is still less than or equal to the buffer size, more actual measurement data may be viewed without having to acquire additional data.

### 7.5.2 The Table

The table display is ideal for viewing many data at once and in numeric format. Unlike with the gauges, the table allows selecting ALL data, ALL tracking frequencies, and ALL signals, and may be displayed in a large spreadsheet. Either individual columns or individual rows, or the entire table may be copied to the clipboard of the operating system.

**Right-clicking** anywhere in the table produces a popup menu with the following options:

- Copy Selection 

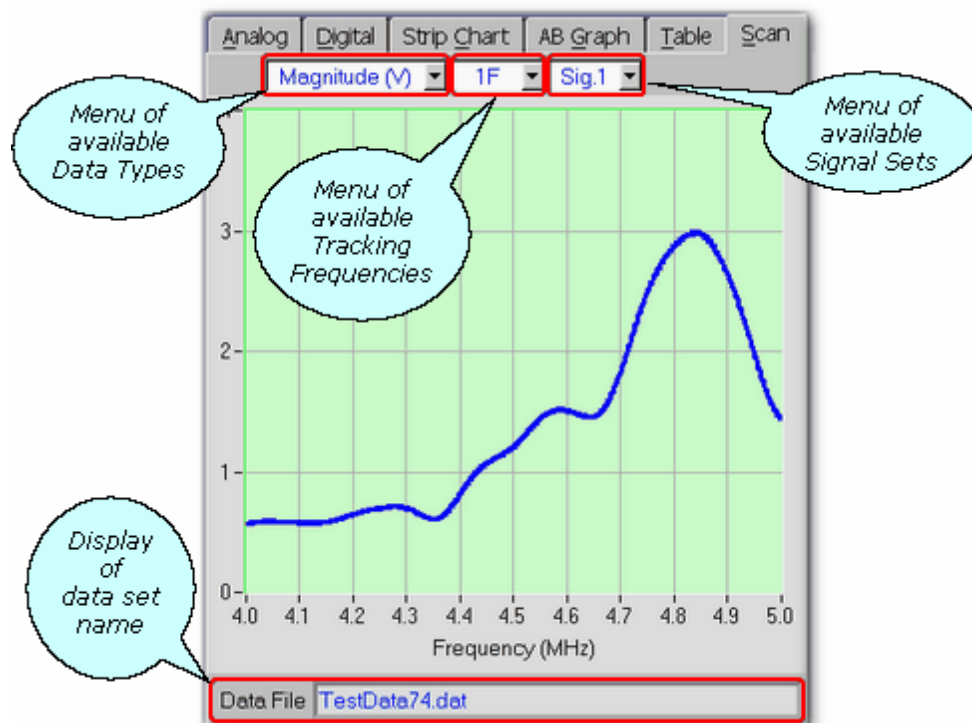
- Precision > 0, 0.0, 0.00, ... [7-14](#)
- Help [7-14](#)

**Copy Selection** copies the selected range of data (including column headers regardless of row selection) onto the computer clipboard, so that it may easily be pasted back into some other document.

**Precision > 0, 0.0, 0.00, ...** changes display precision of the entire table to the one selected from the available choices.

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the Data Table.

## 7.6 Scan Graph








*The data graph on the Scan tab.*

The *Scan* tab is for viewing and analyzing data acquired via scanning.

The following topics describe in detail the various controls and main components of the *Scan* tab:

- [View Data Type](#) [7-17](#) | [Tracking Frequency](#) [7-18](#) | [Signal Set](#) [7-18](#) | [Background](#)
- [The XY Graph](#) [7-15](#)
- [Data File](#)

Below are detailed descriptions of the popup menu options that are available when right-clicking the mouse pointer on the tab's label or anywhere else on the tab, except on a control or the graph area.

- Detach/ReAttach 'Scan Panel' 
- Copy 
- Save As... 
- Print... 
- Help 

**Detach 'Scan Panel'** frees the Scan tab from the main window of the RAM-5000-SNAP user interface and makes the scan graph available on a separate, freely moving and sizable window. To confine the graph back to a tab on the main window, simply close the window by clicking the [x] button on the right of the title bar, or select **ReAttach 'Scan Panel'** from the popup menu when right-clicking inside the window. *The option to detach the Scan tab is only available in the Advanced Edition of the RAM-5000-SNAP User Interface.*

**Copy** creates a bitmap image of the panel (*without the frame and title bar*) and copies the image to the computer clipboard.

**Save As...** creates a bitmap image of the main window (*without the frame and title bar*) and opens a file/folder browser for you to save the image to a specific folder under a user-defined filename. You may choose between four different image file formats:

- \*.PNG --- PNG Bitmap (LZ77 Compression)
- \*.JPG --- JPEG Bitmap (90% Quality, Progressive/Interlaced)
- \*.TIF --- TIFF Bitmap (RLE Compression)
- \*.BMP --- Windows Bitmap (Uncompressed)

When specifying the filename, the appropriate file extension must be added (not case-sensitive), or the image format will default to a Windows Bitmap. The same applies, if some other extension is added. The available image formats are ordered by resulting file size, starting with the smallest.

**Print...** creates a bitmap image of the main window (*without the frame and title bar*) and opens a Print Options dialog for you to send the image to a printer.

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the Scan tab/window.

### 7.6.1 The XY Graph

The data graph is for monitoring data acquisition during a scan, and provides the capability to view and analyze acquired data after a scan, including data reloaded from a file. Several options are available to modify various graph and data plot properties, including interactive zooming. For example, the user may zoom both axes simultaneously using the left mouse



button to draw an *imaginary* rectangle on the plot region while holding down the **Ctrl-key**. To undo the last zoom step, hold down the **Shift-key** and **left-click** anywhere on the graph.

**Left-double-clicking** the mouse pointer over either axis opens a dialog box with properties specific to the respective axis (see Axis Properties [7-19](#)).

**Right-clicking** the mouse pointer over either axis produces a context popup menu showing all options available for the selected axis. From this menu, you may also open a dialog box for editing additional Axis Properties [7-19](#) (*same as if left-double-clicking*).

**Right-clicking** anywhere on the data plot region produces a popup menu showing options for both axes. In addition, from this menu, you may open another dialog box for editing all Graph Properties [7-20](#) at once, including various data plot properties.

Below are descriptions of the popup menu options that may be seen, depending on where on the graph you right-click the mouse pointer.

- X,Y-Axis > Auto Range [7-16](#)
- X,Y-Axis > Zoom > Interactive [7-16](#)
- X,Y-Axis > Zoom > Full Range [7-16](#)
- X,Y-Axis > Show Grid [7-17](#)
- X,Y-Axis > Log Scaling [7-17](#)
- X,Y-Axis > Properties... [7-17](#)
- Properties... [7-17](#)
- Help [7-17](#)

**X,Y-Axis > Auto Range** enables or disables auto *scaling* mode for the respective axis. In this mode, the Y-axis range is automatically (and dynamically during a scan) adjusted to match the range between the smallest and the largest data values. The X-axis lower limit will always correspond to the scan range start value, whereas the X-axis upper limit matches the current scan parameter value (during a scan) or the scan range stop value. Enabling this mode automatically invalidates all zoom options and enables **Auto Divisions** for the respective axis. The **Divisions** setting may also be manually controlled from the Axis Properties [7-19](#) dialog. Disabling the Auto Range mode locks the present limit values of the respective axis.

**X,Y-Axis > Zoom > Interactive** enables or disables interactive zooming for the respective axis. Once enabled, the upper and lower limits of this axis may be adjusted interactively using the left mouse button by drawing an *imaginary* elongated rectangle on the plot region. The most recent zoom action may be undone by **left-clicking** anywhere on the graph while holding down the **Shift-key**. Each successful zoom action automatically disables zooming for the respective axis, so that no additional zooming may occur by accident. To perform additional interactive zooming, it must first be enabled. Enabling this mode automatically invalidates Auto Range and Zoom > Full Range. Disabling this mode (for example, if activated by accident) removes the zoom activation, but changes nothing else.

**X,Y-Axis > Zoom > Full Range** resets the limits for the respective axis to the maximum

dynamic range according to the selected Data View or the defined Scan Limits. Invoking this action automatically invalidates Auto Range and Zoom > Interactive.

**X,Y-Axis > Show Grid** enables or disables the display of the **major grid** (and **minor grid** if activated) for the respective axis. The *major* grid line spacing may be set via the **Divisions** setting on the Axis Properties [\[ 7-19 \]](#) dialog.

**X,Y-Axis > Log Scaling** enables or disables *logarithmic* data mapping for the respective axis. In this mode, the limit values of either axis are always rounded up or down to the nearest power of 10.

**X,Y-Axis > Properties...** opens a dialog box with properties specific to the respective axis (see Axis Properties [\[ 7-19 \]](#)).

**Properties...** opens a dialog box for editing all Graph Properties [\[ 7-20 \]](#) at the same time, including various data plot properties.

**Help** opens the RAM-5000-SNAP Help viewer with help specific to the scan data XY Graph.

## 7.7 Common Display Controls

This section describes controls and dialogs which are applicable to all gauges and various graphical displays.

- Data Type view menu [\[ 7-17 \]](#)
- Tracking Frequency view menu [\[ 7-18 \]](#)
- Signal Sets view menu [\[ 7-18 \]](#)
- Axis Properties dialog [\[ 7-19 \]](#)
- Plot Properties dialog [\[ 7-20 \]](#)

### 7.7.1 Data Type

This control is for selecting the data *type* to display in the various gauges (meters), graphs, and the table. The associated drop-down menu lists the different *types* of available data. The standard data include the **Integrator 1** and **Integrator 2** A/D voltages, as well as the calculated **Magnitude** and **Phase** values. If any one (or both) of the auxiliary A/D channels is (are) selected for data acquisition, the corresponding channel is listed as well, as **Aux.Chn1 (V)** and/or **Aux.Chn2 (V)**, or using customized labels and units (see Auxiliary A/D Setup [\[ 6-32 \]](#)). If there are any measurements [\[ 3-6 \]](#) enabled, one additional drop-down menu item with a particular label for each measurement parameter is also listed.

By default, the unit of the **Integrator** and the **Magnitude** data is **volts**. The unit of the **Phase** data is **radians**, but may also be displayed in degrees (see Setting User Interface Preferences [\[ 3-10 \]](#)).

Unlike with the gauges and graphs, the *View Selector* of the Data Table [7-12](#) allows for selecting **All Data** types to be shown at the same time via multiple columns.

### 7.7.2 Tracking Frequency

**Note:** This control is **not visible** if the selected Data View [7-17](#) (e.g., auxiliary A/D or certain measurement parameters) invalidates a tracking frequency view selection, or if Tracking is disabled (Tracking Source [5-5](#) set to NONE) for the selected Signal View [7-18](#).

This control is for selecting the Tracking Frequency for the current Data and Signal views.

If applicable, the associated drop-down menu lists the tracking frequencies that are available for display in the various gauges (meters), graphs, and the table. Whether tracking frequencies are available depends on how receiver frequency Tracking [5-5](#) is set up for a particular Signal Set [6-29](#). For a given signal set, if there is only one tracking frequency enabled/defined, the Tracking Frequency view selector will show only one menu item. *If two signal sets are used, each defining a different tracking frequency, a change of the Signal View selection will automatically update the Tracking Frequency view selector.* However, if Multi-Frequency Tracking [6-27](#) is used, that is more than one tracking frequency have been defined within a particular signal set, the Tracking Frequency view selector drop-down menu shows multiple items, each corresponding to a different tracking frequency definition for this signal.

Unlike with the gauges and graphs, the Tracking Frequency view selector of the Data Table [7-12](#) allows for selecting **All F.** to show the current data *type* and signal view selections for all defined tracking frequencies at the same time via multiple columns.

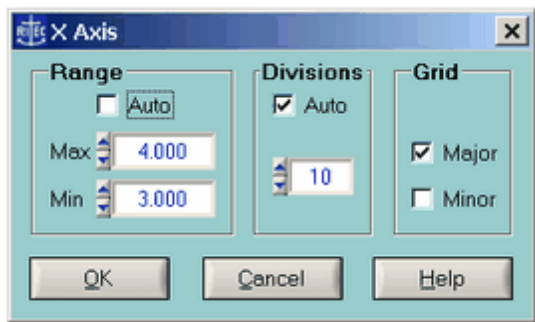
### 7.7.3 Signal Set

**Note:** This control is **not visible** if the selected Data View [7-17](#) (e.g., auxiliary A/D or certain measurement parameters) invalidates a signal view selection, or if only one Signal Set is used.

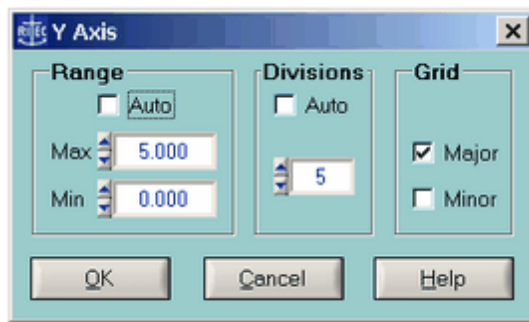
This control is for selecting the signal set from which to display data in the various gauges (meters), graphs, and the table. If applicable, the associated drop-down menu lists the signal settings that are currently defined.

Unlike with the gauges and graphs, the Signal View selector of the Data Table [7-12](#) allows for selecting **All S.**, to show the current data *type* and tracking frequency view selections for all available signal sets via multiple columns.

## 7.7.4 Axis Properties




The X Axis Properties dialog.



The Y Axis Properties dialog.

This dialog box is for setting options specific to a particular plot axis selected by the user (via *left-double-clicking* or via *right-clicking* over it). The Axis Properties dialog allows you to manually control the display **Range** of the selected axis via the numeric inputs labeled **Min** and **Max**. This dialog box is useful for controlling the grid **Divisions** settings, which determine the numeric increment between the displayed axis labels. Most other settings may also be enabled or disabled directly from the respective context popup menu.

The Axis Properties dialog is available for the X and Y axes of the AB Graph as well as the Scan Graph, whereas only for the Y axis of either Strip Chart. Certain axis properties of the strip charts Y axis are further limited, in that the Auto Range and the Auto Divisions options are unavailable. For an alternative *auto ranging* option in each Strip Chart, see **Y-Axis > Zoom** .

Below are descriptions of the various settings found on the Axis Properties dialog box:


### ▪ Range

**Auto** enables or disables the *Auto Range* mode. In this mode, the visible axis range is automatically (and dynamically during data acquisition) adjusted to match the range between the smallest and the largest data values. Enabling this mode automatically invalidates all Zoom options and enables **Auto Divisions**. Disabling this mode locks the present range limits (*Min* and *Max*). The **Min** and **Max** numeric inputs allow for manually controlling the display *Range* of the selected axis. Changing either of these two values automatically invalidates the *Auto Range* mode.

### ▪ Divisions

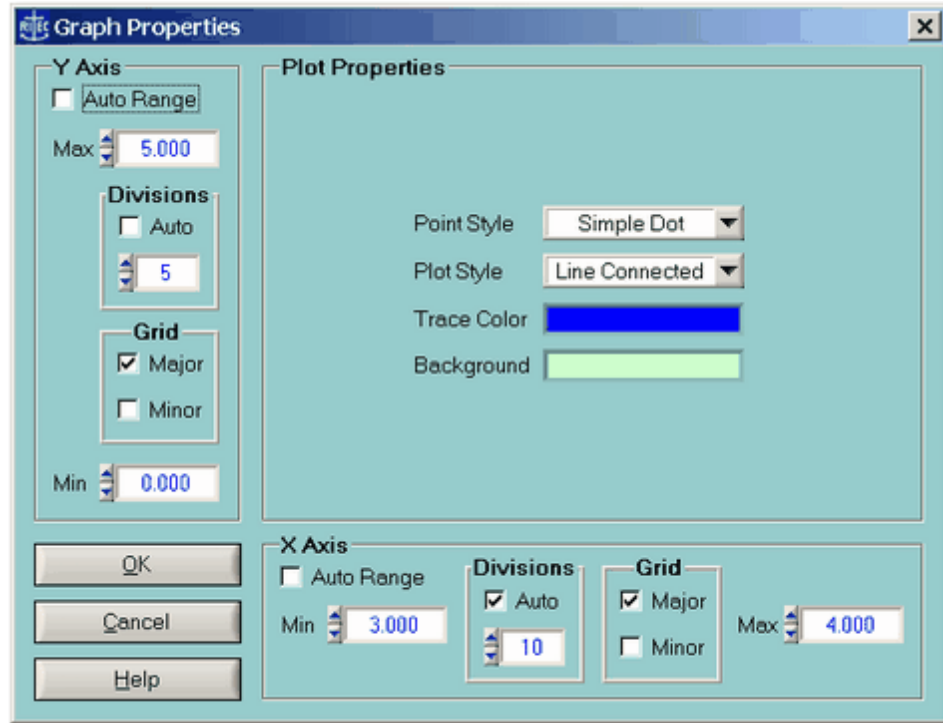
**Auto** enables or disables automatic determination of the optimum numeric increment between the axis labels and the spacing of the major grid. The numeric input is for manually controlling these settings.

### ▪ Grid

**Major** enables or disables the display of the major grid. If the major grid is enabled, **Minor** enables or disables the display of the minor grid. However, if the major grid is disabled, **Minor** is unavailable. The *major* grid spacing may be set via the Divisions  settings, whereas the line spacing of the *minor* grid is always automatically set. The display of the

major grid may also be enabled or disabled from various context popup menus (for example, see **X,Y-Axis** > Show Grid<sup>7-17</sup> for the Scan Data Graph).

## 7.7.5 Graph Properties



The Graph Properties dialog.

This dialog box is for setting both axes properties and various *plot properties* from one location at the same time. With the exception of the *plot properties*, most settings may also be changed via the Axis Properties<sup>7-19</sup> dialog for the respective axis, or they may be enabled or disabled directly from the respective context popup menu.

The Graph Properties dialog is available for the AB Graph and the Scan Graph.

Below are descriptions of the various settings found on the Graph Properties dialog box:

### ▪ Plot Properties

The **Point Style** determines which marker is used for plotting each single data point. The available markers include a *Simple Dot*, a *Small Square*, and an *Empty Circle*. The **Plot Style** determines whether or not the data point markers are connected. The available styles include *Line Connected* and *Scatter* plotting. The default point and plot styles are a *Line Connected Simple Dot*, which results in a thin solid line. To accentuate a particular data plot, it is recommended to change the Point Style to *Small Squares*, and if the number of data points are very limited, changing the Point Style to *Empty Circles*. The **Trace Color** setting determines the color of the entire plot object, that is, it affects the markers and the connecting line. The **Background** setting determines the color of the entire plot region. All plot properties

may be changed at any time, including during data acquisition.



### ▪ X,Y Axis (Range)

**Auto Range** enables or disables auto *scaling* mode for the respective axis. In this mode, the visible axis range is automatically (and dynamically during data acquisition) adjusted to match the range between the smallest and the largest data values. Enabling this mode automatically invalidates all Zoom options and enables **Auto Divisions**. Disabling this mode locks the present range limits (*Min* and *Max*). The **Min** and **Max** numeric inputs allow for manually controlling the display *Range* of the respective axis. Changing either of these two values automatically invalidates the *Auto Range* mode.

### ▪ Divisions (X,Y Axis)

**Auto** enables or disables automatic determination of the optimum numeric increment between the axis labels as well as the spacing of the major grid. The numeric input is for manually controlling these settings.

### ▪ Grid (X,Y Axis)

**Major** enables or disables the display of the major grid. If the major grid is enabled, **Minor** enables or disables the display of the minor grid. However, if the major grid is disabled, **Minor** is unavailable. The *major* grid spacing may be set via the Divisions  settings, whereas the line spacing of the *minor* grid is always automatically set. The display of the *major* grid may also be enabled or disabled from various context popup menus (for example, see **X,Y Axis** > Show Grid  for the Scan Data Graph).

# Section 8

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*Making Measurements*

## 8 Making Measurements

- Overview [8-2](#)
- Time of Flight and Transit Time [8-2](#)
- Relative Magnitude, Phase, Propagation Times, and Attenuation [8-6](#)
- Nonlinear Parameters [8-10](#)

### 8.1 Overview

The RAM-5000-SNAP User Interface includes features that make it possible for you to make simple measurements.

For example, you may perform measurements of the acoustic time of flight as well as measurements of acoustic amplitude and time-of-flight changes as a function of time. *(For additional types of measurements, you may wish to use the included API Function Library to write custom measurement procedures, e.g., as a function of temperature, pressure, or some other measurable parameter.)*

The following topics outline some of the theoretical background for the available measurements:

- Measurement of Transit Time [8-3](#)
- Measurement of Changes in Transit Time and Attenuation [8-7](#)
- Measurement of Parameter of Nonlinearity [8-10](#) *Beta* [8-10](#)

**Note:** All of the measurements that are implemented within the RAM-5000-SNAP User Interface (as opposed to an add-on module), require the respective setup dialog to remain open throughout the measurement (acquisition and calculation) and analysis (data viewing etc.) process. Closing a measurement dialog will terminate the respective measurements and calculations, and will remove the associated data views.

### 8.2 Time of Flight and Transit Time

The Time of Flight Measurements feature allows you to determine absolute acoustic time quantities based on a linear least squares analysis of phase-versus-frequency data. You can measure the Time of Flight of a single acoustic pulse or echo, and the Transit Time through a sample using two or more echoes, which is discussed in Measurement of Transit Time [8-3](#).

You configure acoustic time calculations and view measurement results on the Time of Flight Measurements Panel [8-5](#), which can be accessed from the Measurements menu of the



Main Menu 

### 8.2.1 Measuring Transit Time

The time between the creation of an RF burst from a continuous wave (CW) source and the arrival of an acoustic signal, generated by this burst, is a simple function of the phase of the signal:

$$T_{Ph} = \frac{\phi_r}{2\pi F} \quad (8-1)$$

where  $\phi_r$  is the phase of the signal and  $F$  is the frequency of the burst. There is a difficulty in that  $\phi_r$  is a large phase angle (many times  $2\pi$ ). It could be determined unambiguously by increasing the frequency from zero to the desired value while keeping track of the phase during this procedure. This is very seldom possible because of bandwidth considerations in the electronics and transducer. In cases where the absolute magnitude of the phase angle can be approximated, the time obtained can be used to calculate the acoustic phase velocity. The more usual approach, however, is to use the relationship:

$$T_M = \frac{\Delta\phi_r}{2\pi\Delta F} \quad (8-2)$$

Thus the time is calculated from the slope of the phase versus frequency curve and this can be done within the constraints of the tuned transducer elements and the bandwidth of the electronics. The time obtained in this way may be used to calculate the acoustic group velocity. In most experimental situations, the group velocity and phase velocity are equal. This implies a straight-line relationship for phase as a function of frequency. The most common exception to this is when strong multiple scattering occurs from objects near the measurement wavelength in size. In this situation, strong attenuation is also present.

Unfortunately, the time thus obtained consists of all the time delays and phase shift mechanisms from the generation of the CW used to produce the pulse to the actual quadrature phase sensitive detection process.

$$T_M = T_{AC} + T_{Diff} + T_{Elec} + T_{PhBond}(F) + T_{PhTrans}(F) \quad (8-3)$$

where  $T_{AC}$  refers to the acoustic time of flight,  $T_{Diff}$  includes diffraction effects,  $T_{Elec}$  includes all electronic transit times,  $T_{PhBond}$  includes phase shifts which are a result of the acoustic bond, and  $T_{PhTrans}$  takes into account the phase shifts at the transducer/sample interface.

The effects of diffraction on the phase slope at normal ultrasonic frequencies is small. Therefore, this term is usually neglected for group velocity calculations. The electronic transit time can be removed by making measurements on two echoes. The measured time to the

first echo is simply subtracted from the time to the second and the difference is the acoustic time between them. Unfortunately, more reflections in the transducer bond sample interface occur for later echoes and the phase shifts for these reflections are frequency dependent. Under certain circumstances, these shifts can be measured or calculated. A good discussion of the theory is given by H.J. McSkimin [1] and a general discussion of ultrasonic velocity measurements is presented by E.F. Papadakis [2].

One simple way to deal with these frequency phase shifting reflections at the transducer is to use an acoustic delay line (buffer rod). Such an arrangement is shown in Figure 8-1.

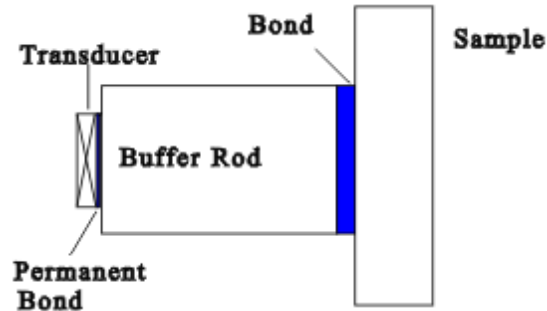


Figure 8-1. Typical acoustic delay line arrangement.

Usually the bond between the sample and the rod can be made very thin and neglected. The buffer rod must be long enough to allow at least two sample echoes to appear before the second buffer rod echo interferes with the sample signals. The acoustic delay could also be a liquid; in which case the bond is non-existent. Measuring the difference in time between two sample echoes removes the time in the acoustic delay line.

**Note:** **Caution!!!** Care must be taken when using standard commercial transducers, especially if the assembly is placed directly on the sample. Commercial transducers have wear plates, acoustic impedance matching layers, and damping materials which make it difficult to predict the phase shift of a sound pulse at the sample/transducer interface.

The time for sound to travel through one thickness of the sample is calculated from

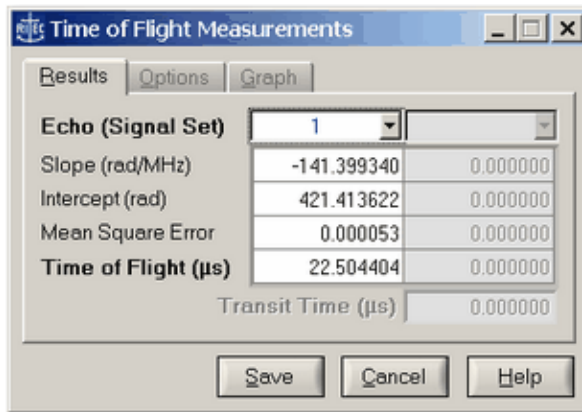
$$\text{Transit Time} = \frac{\left( \frac{\Delta\phi_{r2}}{\Delta F} - \frac{\Delta\phi_{r1}}{\Delta F} \right)}{4\pi(N_2 - N_1)} \quad (8-4)$$

where  $N_2$  is the echo number of the later echo and  $N_1$  is the number of the earlier one. The term  $\Delta\phi_{r2}/\Delta F$  represents the slope of the phase frequency curve for the later echo and a similar term is used for the first echo.

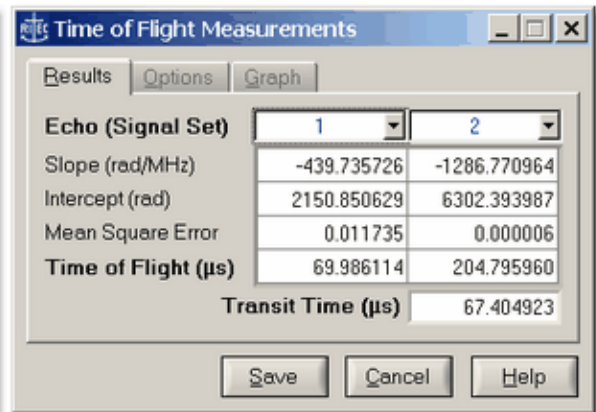
It is recommended that a frequency scan range be as wide as possible for a given transducer because the measurement of slope is more subject to noise and spurious effects than simple voltage measurements. The wide frequency range tends to average out any local variations that may temporarily distort the slope of the curve. These spurious effects may come from inhomogeneities in the sample or from electronic effects such as unequal gain in the two-phase detector/integrator channels or errors in the reference phases of the quadrature detection circuitry. It is possible to write a computer programs that can cancel out the electronic effects. This measurement program does not attempt to do so. In any case, a wide sweep range will tend to minimize these effects.

1. H.J. McSkimin and P. Andreatch, J. Acoust Soc. Am., 34, 609, 1962.  
 2. M. Papadakis, Physical Acoustics Vol. XII (Mason & Thurston Editors), Academic Press, New York, 1976.

### 8.2.2 Measurement Panel



The Time of Flight Measurements window when analyzing a single echo.



The Time of Flight Measurements window when analyzing multiple echoes.

The Time of Flight Measurements panel displays measurement and calculation results. These are updated automatically after each frequency scan, or upon reloading a previously acquired set of frequency scan data. If only one data acquisition signal is set up, then only the left column of the table will be populated, and no transit time calculation occurs.

When the Time of Flight Measurements panel is opened, the data acquisition Run Mode <sup>6-20</sup> is automatically set to **Scan**, and the Scan Type <sup>6-8</sup> is set to **Frequency**, if either are different. If the Run Mode is changed while the Time of Flight Measurement is active, that is, its panel is visible, the Measurement Panel will disappear. It will automatically reappear once Run Mode > **Scan** is restored. The same applies to changing the Scan Type, since the Time-of-Flight Measurement procedure, that is implemented as part of the RAM-5000-SNAP User Interface is based entirely on the analysis of frequency scan data.

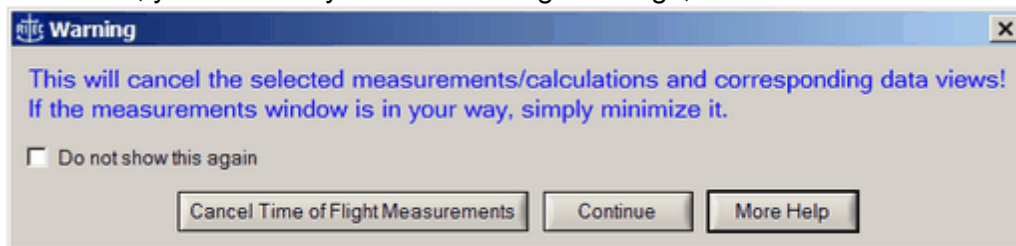
**Note:** The calculations are based on linear fitting the phase-versus-frequency data using the least squares method.

For convenience, you may copy the transit time data to the computer clipboard via mouse-right-clicking etc.

Once Time of Flight data are obtained, the **Save** button is enabled, which allows to save all calculated data to a text file in a simple table format.

**Advanced Edition:** Two additional tabs are available; an **Options** panel for setting fitting options, and a **Graph** panel for selecting optional data to be plotted in the scan data graph. The optional plot data include the Residuals and Weights used for fitting, and calculated Phase and Group Delay data. *Customized fitting and graphical analysis of phase-versus-frequency data, including calculation of group and phase delay data.* The **Save** button now also allows to save this additional data.

Closing the Time of Flight Measurements panel, either by clicking the [x] button on the window title bar, or by clicking the **Cancel** button, also terminates the respective measurements and calculations, and removes the associated data views. Click the [\_] button on the window title bar of the measurements dialog instead, if you just want to remove the dialog from the screen but continue using the Time of Flight Measurements feature. Otherwise, you will initially see the warning message, as shown



, to verify your intent. If you click the button labeled **Cancel Time of Flight Measurements**, you are confirming the termination of time-of-flight measurements. Clicking the button labeled **Continue** will allow you to proceed with the present measurements. You can prevent the warning message from showing again by selecting the option "Do not show this again", which is located on the message box itself.

### 8.3 Relative Magnitude, Phase, Time, and Attenuation

The Relative Measurements feature allows you to measure changes in a number of acoustic parameters, such as Transit Time and Attenuation, as a function of time or some experimental variable. Other relative measurable quantities include both integrator outputs as well as signal magnitude and phase. The two most useful Relative Measurements are discussed in Measurement of Changes in the Transit Time and Attenuation [\[ 8-7 \]](#).

You select the Relative Measurement parameter and activate its calculation on the Relative Measurements Setup [\[ 8-9 \]](#) dialog, which can be accessed from the Measurements menu of the Main Menu [\[ 3-4 \]](#).

### 8.3.1 Measuring Changes in Transit Time and Attenuation

#### **Measuring Changes in Transit Time ( $\Delta T$ ) using a Single Signal or Echo:**

Most of the errors expressed in equation 8-3 become constants because the frequency is not changed during the experiment. When the differences between the current acoustic time of flight and the time at the beginning of the test are calculated, these constant errors are removed. The mathematical relationship is:

$$\Delta T = T_1 - T_0 = \frac{\Delta \phi_r}{2\pi F} \quad (8-5)$$

where  $T_0$  is the time from the burst to the received signal at time zero,  $T_1$  is the acoustic time of flight at the time the measurement is made, and  $\phi_r$  is the change in the phase angle.

Because the system is capable of resolving phase angle differences to much better than 0.1 degree (30 picoseconds at 10 MHz), the errors just discussed may not remain as constants during the data acquisition time. The phase shifts in the electronics or transducer arrangement may change with temperature.

#### **Measuring $\Delta$ transit time using Two Signals or Echoes:**

A measurement using two echoes will remove these unwanted effects because both echoes will suffer the same shifts.  $\Delta$ transit time is then calculated from the difference between  $\Delta T_2$  for the second echo and  $\Delta T_1$  for the first.

$$\Delta \text{transit time} = \frac{\Delta T_2 - \Delta T_1}{2(N_2 - N_1)} = \frac{(\phi_{r2}(t) - \phi_{r1}(t)) - (\phi_{r2}(0) - \phi_{r1}(0))}{4\pi F(N_2 - N_1)} \quad (8-6)$$

where  $\phi_{ri}(t)$  is the phase of the  $i^{\text{th}}$  signal at time  $t$  and  $\phi_{ri}(0)$  is the phase at time zero.

$\Delta$ transit time is the change in time for the acoustic pulse to travel from one side of the sample to the other (not a full round trip).

#### **Measuring Changes in the Attenuation:**

When a signal is measured, the computer program is designed to calculate the logarithmic ratio of the amplitude of the present signal to its time zero amplitude. This is displayed in units of dB.

When two echoes are selected the calculation proceeds quite differently. At time zero the attenuation per transit is given by:

$$\text{Attenuation} = \frac{20}{2(N_2 - N_1)} \text{Log} \left( \frac{G_1 A_1(0)}{G_2 A_2(0)} \right) \text{ dB per transit} \quad (8-7)$$

where  $G_1$  and  $G_2$  are the two gain settings, and  $A_1(0)$  and  $A_2(0)$  are the amplitudes of the echoes at time zero. The change in attenuation is given by:

$$\Delta \text{Attenuation} = \frac{10}{(N_2 - N_1)} \text{Log} \left( \frac{A_1(0) A_2(t)}{A_2(0) A_1(t)} \right) \text{ dB per transit} \quad (8-8)$$

Notice that the gain terms  $G_1$  and  $G_2$  disappear when we calculate the change in attenuation.  $A_1(t)$  and  $A_2(t)$  are the echo amplitudes at time  $t$ . The absolute acoustic attenuation in a solid sample is considered a very difficult parameter to measure. There are problems in determining the amount of energy reflected at each interface, diffraction effects, lack of parallelness, and acoustic bond character to consider. However, the validity of a measurement of the change in attenuation such as described here is much greater since most of these problems remain fixed over the course of an experiment and cancel out in Equation 8-8.

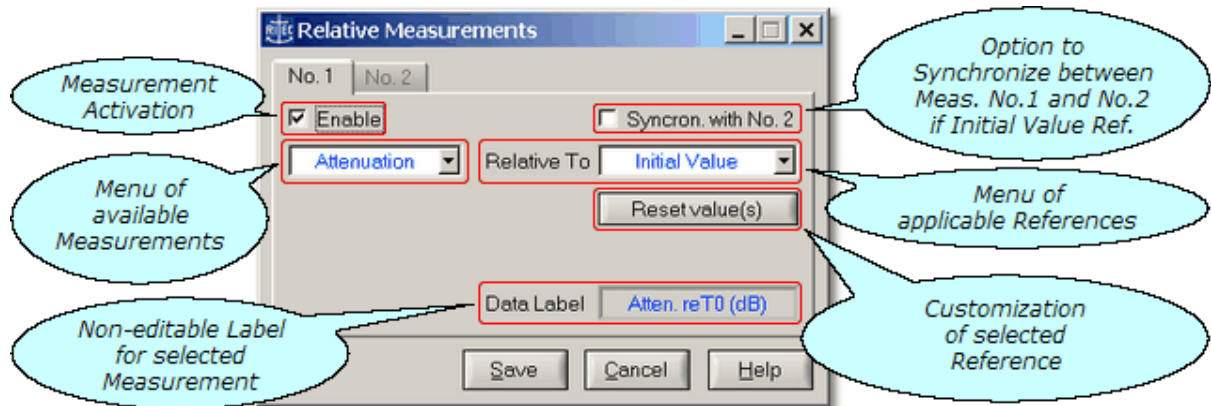
If the user has measured the thickness of the sample ( $h$ ) in cm,  $\Delta\alpha$  may be calculated from:

$$\Delta\alpha = \frac{\Delta \text{Attenuation } n}{h} 0.1151 \text{ nepers per cm}, \quad (8-9)$$

where the constant (0.1151) is used to convert from dB to nepers.

**Note:** The procedure implemented in the RAM-5000-SNAP software to measure changes in the attenuation using two echoes reports an increase in attenuation per transit as a negative value, and a decrease in attenuation per transit as a positive value.

### 8.3.2 Measurement Setup



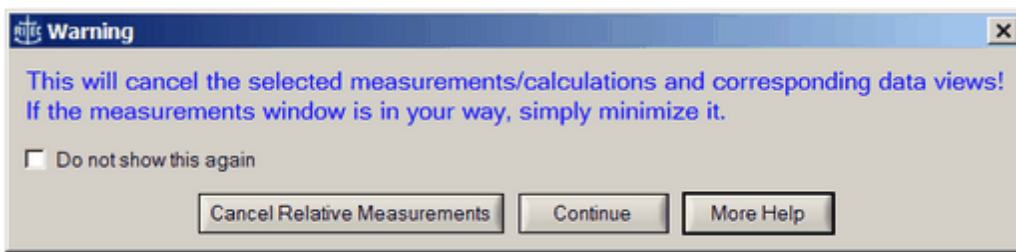
The Relative Measurements setup window.

The Relative Measurements setup dialog is for setting up relative data calculations. The available data options include: *Integrator 1*, *Integrator 2*, *Magnitude*, *Phase*, *Delay Time*, *Transit Time*, and *Attenuation*. The base data (Integrators 1 and 2, Magnitude and Phase) may be calculated relative to some *Initial Value*, a user-defined *Fixed Value*, or another *Tracking Frequency*<sup>[6-27]</sup> and/or *Signal Set*<sup>[6-29]</sup>. The measurement data options *Delay Time*, *Transit Time*, and *Attenuation* may be calculated only relative to some *Initial Value*. In addition, *Transit Time* and *Attenuation* measurements always require a minimum of two Signal Sets and will not be available otherwise. The Initial Value may be reset at any time via the button, labeled "Reset value(s)". The user interface maintains initial value buffers for all measurement, which allows switching the measurement data without losing coherence between them. Relative measurements may be used in all available acquisition run modes and scan types. Up to two simultaneous measurements can be enabled, which may optionally be synchronized if both are configured Relative To *Initial Value*.

**Note:** At present, data for the measurement selected on tab *No.1* may be viewed only through *Channel A*, and the data for the measurement selected on tab *No.2* may be viewed only through *Channel B* of the various meters (Analog and Digital Gauges) and graphs (Strip Charts and AB Graph).

Once measurement data are obtained, the **Save** button is enabled, which allows to save all available data to a data file.

Closing the Relative Measurements dialog, either by clicking the [x] button on the window title bar, or by clicking the **Cancel** button, also terminates the respective measurements and calculations, and removes the associated data views. Click the [ ] button on the window title bar of the measurements dialog instead, if you just want to remove the dialog from the screen but continue using the Relative Measurements feature. Otherwise, you will initially see the warning message, as shown



, to verify your intent. If you click the button labeled **Cancel Relative Measurements**, you are confirming the termination of presently enabled relative measurements. Clicking the button labeled **Continue** will allow you to proceed with the present measurements. You can prevent the warning message from showing again by selecting the option "Do not show this again", which is located on the message box itself.

## 8.4 Nonlinear Parameters

*Advanced Edition only*

The Nonlinear Parameter Measurements feature allows you to investigate acoustic parameters, that are based on user-defined ratios of signal magnitudes at specific detector frequencies, as a function of time or some experimental variable. An example of a nonlinear acoustic parameter is discussed in Measurement of Beta <sup>8-10</sup>.

You define the Nonlinear Parameter and activate its calculation on the Nonlinear Parameter Measurements Setup <sup>8-12</sup> dialog, which can be accessed from the Measurements menu of the Main Menu <sup>3-4</sup>.

### 8.4.1 Measuring Beta

A perfectly linear elastic relationship between the stress and the strain in a solid would be accurately described by the well-known Hooke's law

$$\sigma = C\varepsilon, \tag{8-10}$$

where  $\sigma$  is the stress,  $\varepsilon$  is the strain, and  $C$  is a material constant, namely the elastic modulus. Most *real* solids, however, exhibit over some range a stress-strain characteristic which involves a certain degree of nonlinearity. To describe this type of mechanical behavior, Hooke's law is usually expanded by including higher order elastic moduli [1]. Considering only the lowest order nonlinearity, the stress-strain dependence may be written as

$$\sigma = C\varepsilon - D\varepsilon^2. \tag{8-11}$$

If Equation 8-11 is used to derive a wave equation it can be shown [2] that the parameter  $\beta =$



$D/C$ , which represents a measure of the degree of material nonlinearity, is related to the amplitudes of the fundamental,  $A_1$ , and second harmonic,  $A_2$ , wave components of a sinusoidally varying propagating plane stress wave, that is

$$\beta = K \frac{A_2}{A_1^2}. \quad (8-12)$$

In Equation 8-12,  $K$  represents a constant the value of which depends on wave propagation parameters and material properties that are typically known. For example, if Equation 8-11 is inserted into the equation of motion describing the propagation of an elastic stress wave through an unbounded homogeneous continuous solid medium in one dimension, and assuming for simplicity also a one-dimensional small strain, the nonlinear wave equation in the form

$$\frac{\partial^2 u}{\partial t^2} = v^2 \left( 1 + \beta \frac{\partial u}{\partial a} \right) \frac{\partial^2 u}{\partial a^2} \quad (8-13)$$

can be obtained. In Equation 8-13,  $u$  is the particle displacement,  $t$  is the time,  $v$  is the wave velocity, and  $a$  is a coordinate along the propagation direction. Next, assuming a sinusoidally varying propagating elastic plane wave, the solution of Equation 8-13 can be given as [3]

$$u = A_1 \sin(ka - \omega t) + A_2 \cos(2ka - 2\omega t), \quad (8-14)$$

where

$$A_2 = \frac{\beta}{8} k^2 a A_1^2, \quad (8-15)$$

is the fundamental frequency, and  $k = \omega/v$  is the propagation constant. According to Equation 8-15 it follows immediately that the parameter  $\beta$  can be calculated from the acoustically measurable quantities  $A_1$  and  $A_2$  as well as the knowledge of  $v$  and  $a$ , that is

$$\beta = \frac{8}{k^2 a} \frac{A_2}{A_1^2}. \quad (8-16)$$

The RAM-5000-SNAP User Interface allows you to define nonlinear acoustic measurement parameters such as the one according to Equation 8-12, or any other type of parameter that is based on a user-defined proportionality constant times a ratio of acquired signal magnitude data at specially selected acquisition frequencies (see Nonlinear Parameter Setup [8-12](#)).

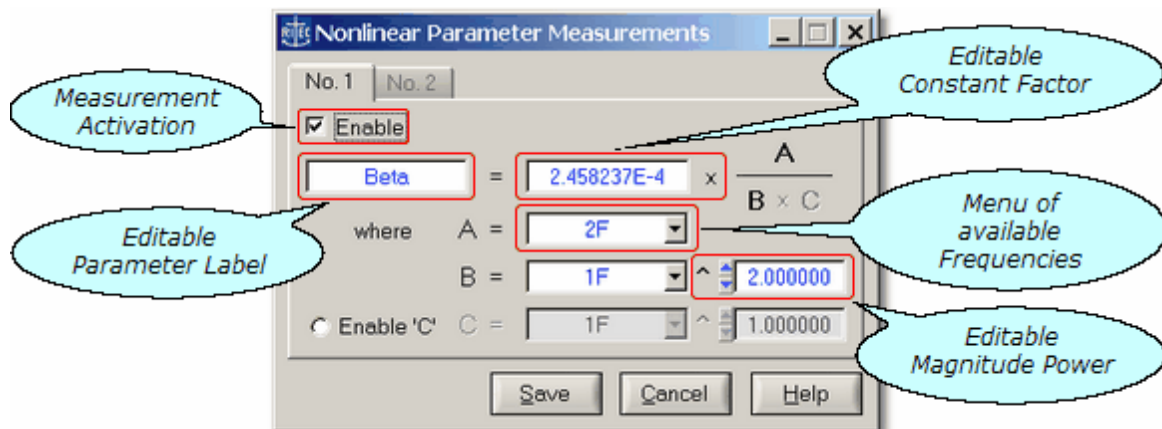
1. L. D. Landau and E. M. Lifshitz, *Theory of Elasticity*, Pergamon Press, Oxford and New York, 1970.

2. M. A. Breazeale and J. Philip, "Determination of third-order elastic constants from ultrasonic harmonic generation measurements", *Physical Acoustics XVII*, Academic Press, New

York 1984.

3. M. A. Breazeale, "Anharmonicity, Piezoelectricity, and Solid State Nonlinearity", Review of Progress in Quantitative Nondestructive Evaluation, Vol. 10B, 1797-1803, D. O. Thompson and D. E. Chimenti, eds., Plenum Press, New York (1991).

## 8.4.2 Parameter Setup



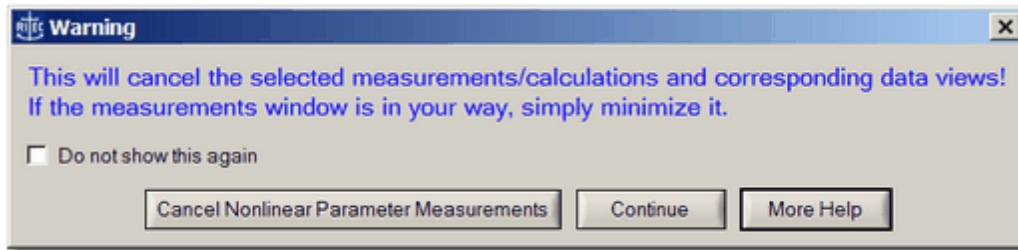
The Nonlinear Parameter Measurements setup window.

The Nonlinear Parameter Measurements dialog allows you to set up nonlinear parameter calculations. A nonlinear parameter is typically defined as the ratio between two or three signal magnitudes at specific acquisition frequencies, times a constant encompassing various material properties. The general parameter structure used is  $Constant * A / (B * C)$ , where  $A$ ,  $B$ ,  $C$  represent signal magnitudes at selected tracking frequencies, and where  $B$  and  $C$  have user-defined powers, all of which allows for numerous definitions. Up to two parameters may be defined, according to the tabs, labeled No.1 and No.2. In addition, each parameter may be assigned a custom data label. Nonlinear parameter calculations may be used in all of the available data acquisition Run Modes [6-20](#) and Scan Types [6-8](#). For each *enabled* parameter, calculations are performed during data acquisition or automatically upon reloading of previously acquired data. Calculations are updated whenever either parameter is redefined.

**Note:** At present, measurement data for the parameter definition on tab *No.1* may be viewed only through *Channel A*, and the data for the parameter definition on tab *No.2* may be viewed only through *Channel B* of the various meters (Analog and Digital Gauges) and graphs (Strip Charts and AB Graph).

Once measurement data are obtained, the **Save** button is enabled (not dimmed), which allows to save all available data to a data file.

Closing the Nonlinear Parameter Measurements dialog, either by clicking the [x] button on the window title bar, or by clicking the **Cancel** button, also terminates the respective measurements and calculations, and removes the associated data views. Click the [ ] button on the window title bar of the measurements dialog instead, if you just want to remove the dialog from the screen but continue using the Nonlinear Parameter Measurements feature. Otherwise, you will initially see the warning message, as shown



, to verify your intent. If you click the button labeled **Cancel Nonlinear Parameter Measurements**, you are confirming the termination of presently enabled nonlinear parameter measurements. Clicking the button labeled **Continue** will allow you to proceed with the present measurements. You can prevent the warning message from showing again by selecting the option "Do not show this again", which is located on the message box itself.

# Section 9

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*Instrument API*

## 9 Instrument API

This section contains information on how to program the RAM-5000-SNAP using the provided instrument control and data acquisition API (Application Programming Interface).

The RAM-5000-SNAP Instrument API help is divided into the following sections.

- [LabVIEW Reference](#) (click to open or see *ram5Kapi\_LV.pdf*)
- [MATLAB Reference](#) (click to open or see *ram5Kapi\_ML.pdf*)

*Version 1.0.98 Rev.6 (February 2023)*

# Section 10

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*Theory of Operation*

## 10 Theory of Operation

The following sections discuss in detail the theory of operation of the RAM-5000-SNAP system:

- Signal Processing <sup>[10-2]</sup>
- Superheterodyne Receiver and Phase-Sensitive Detector <sup>[10-3]</sup>
- Analog Integration <sup>[10-4]</sup>
- Reduction of Measurement Errors <sup>[10-7]</sup>

### 10.1 Signal Processing

Figure 10-1 shows the block diagram of the instrumentation approach used in the RAM-5000-SNAP system.

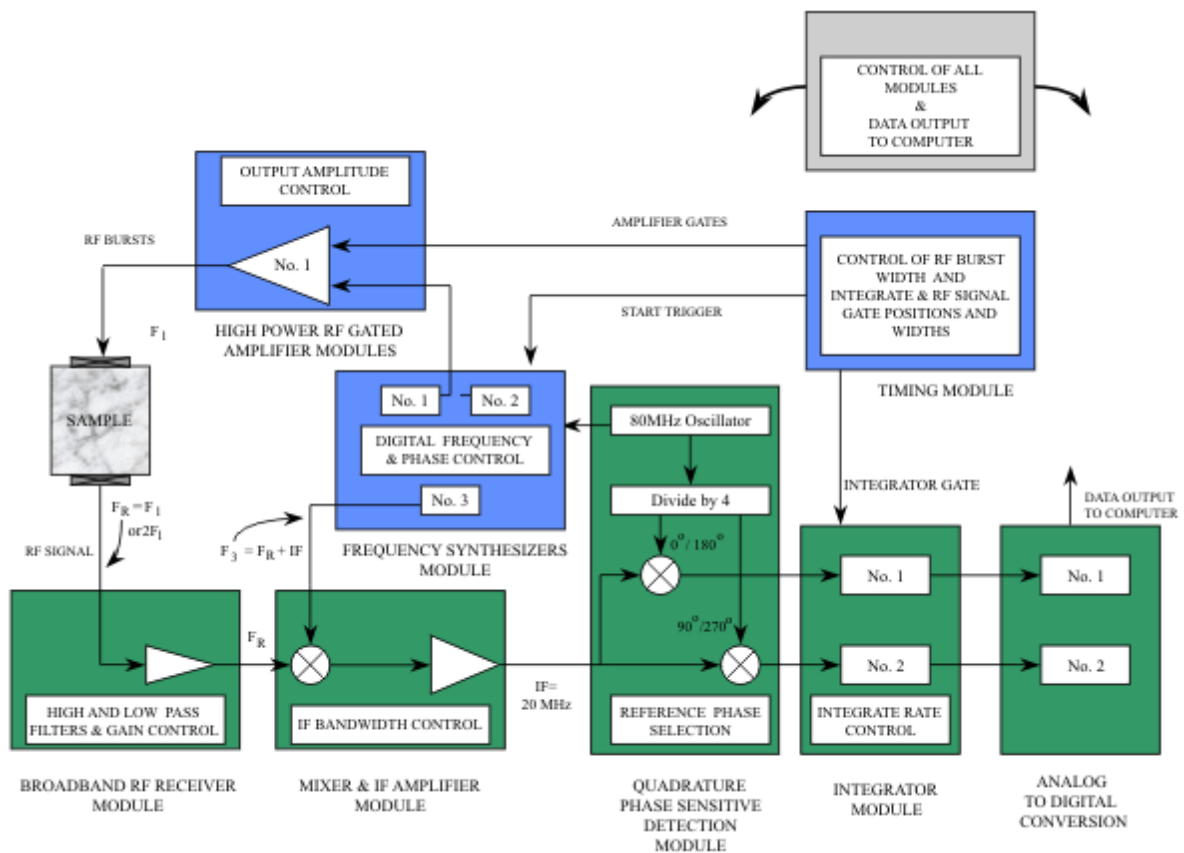


Figure 10-1. Block diagram of RAM system.

The main input to the gated amplifier is obtained from Synthesizer No.1. Synthesizer No.2 may also be used and added to the output of the first. However, in the following discussion, it will be assumed that only the first synthesizer is utilized, and its output is given by:

$$\text{Transmit Signal} = A_{S1} \cos(2\pi F_{S1} t), \quad (10-1)$$

where  $t$  is taken as zero at the beginning of each burst where the synthesizers are turned on.

## 10.2 Superheterodyne Receiver and Phase-Sensitive Detector

The apparatus uses a superheterodyne receiver equipped with a pair of phase-sensitive detectors to process the received ultrasonic signals following wide band amplification. The first step of superheterodyne reception involves a multiplication operation that preserves the phase relationships of the received ultrasonic signals while "shifting" their carrier frequencies to an intermediate-frequency (IF) band. The frequency "shifting" is accomplished using an analog RF multiplier circuit. Following amplification and filtering by the IF amplifier, the ultrasonic signals are "shifted" again to zero (baseband) RF frequency using a pair of matched RF multiplier circuits which function as phase sensitive detectors. The two multipliers are driven by separate gated "reference" signals at the IF frequency. The two IF "reference" signals are at exactly the same frequency, but are shifted one from the other by 90 electrical degrees. Following multiplication by the two IF "reference" signals (referred to as quadrature phase detection), the ultrasonic signals are filtered using low-pass filters and integrated using matched gated integrators. The outputs of the integrators are converted to digital format using two 16-bit digital-to-analog (A/D) converters. Further processing, then needed to determine amplitude and phase of the signal, is accomplished using a personal computer.

To gain more insight into the operation of the phase-sensitive receiver circuitry, it is instructive to consider the received ultrasonic information as a narrow-band function. Such a function can be represented as a monochromatic signal at frequency ( $F_r$ ) modulated by a term, which defines the width, amplitude, and shape of the received signal,  $A_r(t)$ . In our implementation of the heterodyne receiver, the signal  $f(t)$  is amplified by the variable-gain (78-dB range) wide-band RF amplifier. The output of the wide-band amplifier is then multiplied by the synthesizer output signal ( $V_{S3}$ ) at frequency ( $IF + F_r$ ) using the analog multiplier (mixer).

$$V_{S3} = A_{S3} \sin(2\pi(IF + F_r)t) \quad (10-2)$$

This assumes that synthesizer three has been set to the expected receive frequency plus IF (20 MHz). The multiplication results in a new signal with a frequency IF. Although the ultrasonic signals received following the interruption of the driving RF signal may have different frequency components than the transmitted frequency, ( $F_{S1}$ ), the phase term  $\phi_{1r}$  is directly related to the transmit phase at time zero. Assuming that the frequency of the received signal can be represented by  $F_r$ , the signal  $f(t)$ , appearing at the input of the Pre-Amp, has the general form:

$$f(t) = A_r(t) \sin(2\pi F_r t + \phi_r) \quad (10-3)$$

where  $\phi_r$  represents the phase shifts in the transducer and sample including the effects of



acoustic transit time. When  $f(t)$  after amplification is multiplied by the synthesizer output in Mixer the resulting voltage is given by:

$$V_{Mixer} = g_2 A_r(t) \cos(2\pi IF t - \phi_r) + High\ Freq.Term \quad (10-4)$$

where the constant  $g_2$  includes the RF gain, the amplitude of the reference  $A_{S3}$ , and the conversion efficiency of the multiplier. The high frequency term of Equation 10-4 involving the frequencies  $(IF + 2F_r)$ , is rejected by the IF amplifier, which has a fixed center frequency of 20 MHz and three computer-selectable bandwidths: 0.4 MHz, 1 MHz, and 4 MHz.

The IF reference signals are obtained by dividing down the synthesizer clock and therefore have a fixed phase angle at time zero near  $0^\circ$ . The  $0^\circ$  reference is given by:

$$Reference_{0^\circ} = A_{Ref} \sin(2\pi IF t) \quad (10-5)$$

The remaining signal, containing the phase of the ultrasonic signal, is amplified and then multiplied by the IF oscillator outputs using the analog multipliers which make up the quadrature phase sensitive detector. The output of the  $0^\circ$  multiplier (Phase Detector. No.1) is given by:

$$PhaseDet.No.1 = g_3 A_r(t) \sin \phi_r + High\ Freq.Term \quad (10-6)$$

where the total gain and conversion efficiencies are all included in the term  $g_3$ . The output of Phase Detector No.2 is given by:

$$PhaseDet.No.2 = g_3 A_r(t) \cos \phi_r + High\ Freq.Term \quad (10-7)$$

Equations 10-5, 10-6, and 10-7 describe the "quadrature phase-sensitive detection" process. The high-frequency terms are effectively removed by the integrators and low-pass filters (not shown in Figure 10-1) that follow the analog Multipliers. Only the low-frequency (base band) terms, involving the phase of the received signal, survive. This analysis has assumed that the local oscillator synthesizer (synthesizer 3) has been set to receive the proper frequency. If this is not the case, the phase detector outputs will contain terms containing the difference frequency between the tuning (LO) frequency and the actual received frequency.

### 10.3 Analog Integration

If the high frequency terms of Equations 10-6 and 10-7 are completely filtered out, the amplitude and phase ( $\phi_r$ ) may be calculated after measuring the instantaneous value of the phase detectors at the center of the signal or where steady state conditions have been achieved. However, if bursts containing a small number of cycles are used, the low-pass filters are not able to remove the high frequency components without smearing the detected signal. It also becomes unclear as to where the instantaneous values should be taken.

A typical situation is shown in Figure 10-2. In this example, the signal represented by the upper trace has slightly more than two complete cycles of RF. The lower trace shows the detected signal, which is at a  $0^\circ$  phase angle with respect to the reference. It is clear that removal of the RF components in the detected outputs without significant distortion of the signal would be difficult.

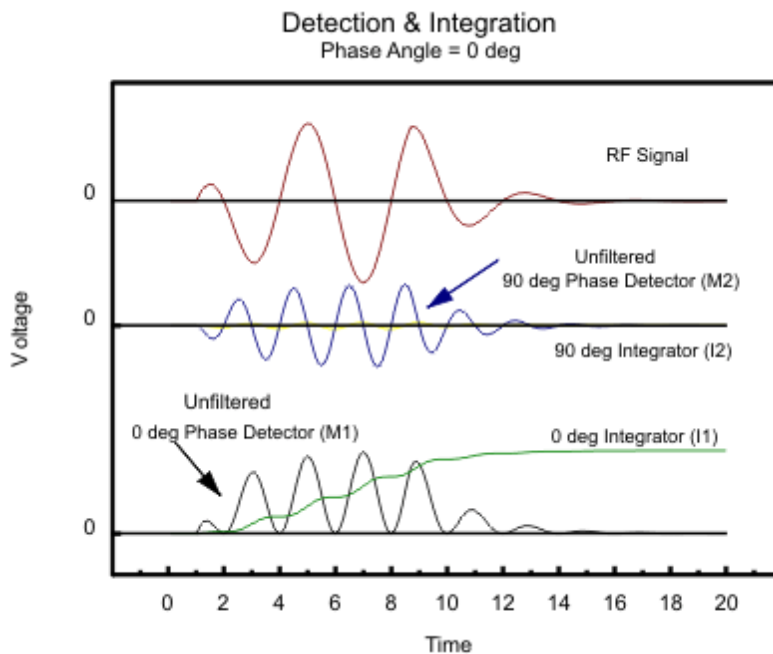


Figure 10-2. RF Receiver, Quadrature Phase Sensitive Detector, and Integrator Outputs for a typical signal with  $\phi_r = 0^\circ$ .

In order to obtain signal amplitude and phase information, the phase-detected signals are processed with an analog integration circuit. This has the value of making the gate position non-critical, removing the RF components, and improving the signal-to-noise ratio. In the example of Figure 10-2, the  $90^\circ$  phase detector, shown in the middle trace, has a zero baseband component and the RF components are integrated to zero. The same signal with a phase angle of  $-45^\circ$  is shown in Figure 10-3.

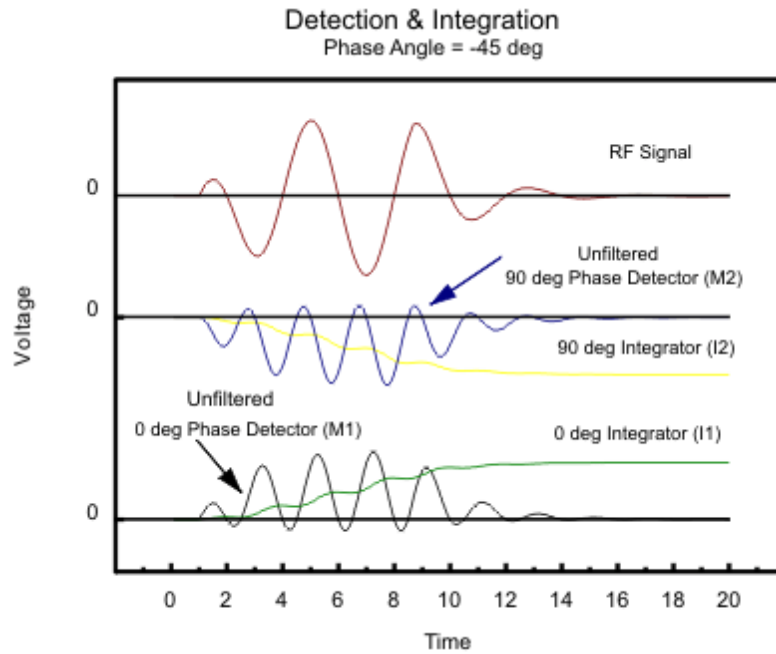


Figure 10-3. RF Receiver, Quadrature Phase Sensitive Detector, and Integrator Outputs for a typical signal with  $\phi_r = -45^\circ$ .

The time limits of the integration are controlled by the integrator gate, and the rate of integration ( $r_I$ ) is under computer control. The gate is positioned so that it begins before and ends after the signal. A sample-and-hold circuit retains the results of the integration until it can be digitized and recorded by the computer. The integrator outputs are given by:

$$I_1 = r_I g_3 \cos \phi_r \int_{t_1}^{t_2} A_r(t) dt \quad (10-8)$$

$$I_2 = r_I g_3 \sin \phi_r \int_{t_1}^{t_2} A_r(t) dt \quad (10-9)$$

where  $I_1$  and  $I_2$  are the outputs of integrators No.1 and No.2 and  $t_1$  and  $t_2$  are the start and stop times defined by the integrator gate. The phase angle of the received signal can be calculated from:

$$\phi_r = \tan^{-1} \left( \frac{I_2}{I_1} \right) \quad (10-10)$$

Notice that in Figure 10-3,  $I_1$  integrates in a positive direction while  $I_2$  goes to the same value in the negative direction yielding a value of -1 for the tangent of the phase angle.

## 10.4 Reduction of Measurement Errors

In the process of developing the measurement procedures and apparatus, we have systematically identified the principal sources of measurement error. Specific calibration and error-correction approaches needed to cope with such errors have also been developed. Some of the measurement errors are caused by the inherent physical limitations of the measurement apparatus and signal-processing methods. Others are caused by factors such as sample shape and composition.

The physical origins of many of the measurement errors and methods for their elimination are identical to those identified by RITEC principals in previous publications. For example, DC offsets and drifts in the circuitry following the phase-sensitive detectors are effectively eliminated by periodically reversing<sup>[6-24]</sup> (shifting by 180°) the electrical phases of the "in-phase" and "quadrature" RF reference<sup>[6-24]</sup> signals applied to the analog multipliers No.3 and 4. In addition, the effects of RF and IF leakage signals can be reduced using calibration<sup>[6-17]</sup> procedures (1). The article in Footnote 1 also describes procedures for dealing with the effects of unequal voltage gains of the two channels used in the phase-sensitive detector. Although the individual electrical components in these channels are carefully matched and adjusted, small variations are inevitable. The same is true of amplitude and phase errors caused by the lack of a perfect quadrature relationship between the two IF "reference" signals applied to the No.3 and 4 analog multipliers.

It has been determined that the dominant source of measurement error in many experiments is the leakage of CW signals generated by the IF oscillator or the leakage of the operating CW frequency through the gated amplifier. The latter are caused by the less-than-perfect Off/On ratio of the gated RF amplifier. In addition, the mechanical and electrical design of many transducers makes them particularly sensitive to magnetic and electric fields generated by other external sources. Such sources typically include distant radio stations, electrical lighting, and other instruments in the laboratory. If the interfering signals are stable in time, then they can be compensated by using appropriate calibration<sup>[6-17]</sup> procedures or removed by averaging<sup>[6-25]</sup>.

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1. H.J. McSkimin, In *Physical Acoustics*, Vol. IA, W.P. Mason ed (Academic Press, New York, 1964), pp. 27-417.

# Section 11

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*Instrument Connectors*

## 11 Instrument Connectors

The entire list of signal connectors and monitors, which may be used at various stages of establishing operating conditions for the system, is divided into the following two groups:

- Front Panel BNCs [11-2](#)
- Rear Panel BNCs [11-4](#)

### 11.1 Front Panel

This section describes the instrument connectors that are located on the front panel of the RAM-5000-SNAP.

- RF BURST NO.1 HIGH POWER OUT [11-2](#)
- RF BURST NO.1 MONITOR [11-2](#)
- RF BURST NO.2 HIGH POWER OUT [11-3](#)
- RF BURST NO.2 MONITOR [11-3](#)
- RECEIVER INPUT NO.1 [11-3](#)
- RECEIVER INPUT NO.2 [11-3](#)
- RECEIVER RF MONITOR [11-3](#)

#### 11.1.1 RF BURST NO.1 HIGH POWER OUT

***Impedance: Nominally 50 Ohms***

Gated amplifier high-power output signal.

Please note, proper electrical impedance matching between the gated amplifier output connector and the transducer input connector is critical for optimum energy transfer and to preserve optimum burst shape quality.

#### 11.1.2 RF BURST NO.1 MONITOR

***-60 dB into 50 Ohms***

To check the number of cycles in a burst and/or to observe the general quality of the burst shape.

If the gated amplifier high-power output signal [11-2](#) is coupled into a 50 Ohm load, the RF Burst Monitor signal provides an accurate representation of the high-power signal at -60 dB. That means, if a transducer connected to the gated amplifier output has an electrical impedance of 50 Ohm, the RF Burst Monitor may be used to determine various characteristics of the transducer drive signal. However, often, laboratory-type transducers and commercially available ones do not or cannot meet the 50 Ohm impedance requirement.

In such a case, it would be better to probe the RF drive signal at the transducer input using an electrically matched 3-pole network, instead of relying on the RF Burst Monitor. Probing the RF drive signal at the transducer input would also be appropriate if an attenuator or similar device is used between the gated amplifier output and the transducer. RITEC offers a so-called *Signal Sampler*, designated SS-40, which may be used in a variety of cases to probe the high-power RF drive signal at -40 dB near the transducer.

### 11.1.3 RF BURST NO.2 HIGH POWER OUT

***Impedance: Nominally 50 Ohms***

Same as for output No.1 [11-21](#).

### 11.1.4 RF BURST NO.2 MONITOR

***-60 dB into 50 Ohms***

Same as for monitor No.1 [11-21](#).

### 11.1.5 RECEIVER INPUT NO.1

***Impedance: 50 Ohm***

Receiver input channel No.1.

The maximum voltage of the input signal should not exceed 100 mV peak-to-peak.

### 11.1.6 RECEIVER INPUT NO.2

***Impedance: 50 Ohm***

Receiver input channel No.2.

Otherwise, same as for RECEIVER INPUT NO.1 [11-31](#).

### 11.1.7 RECEIVER RF MONITOR

***-20 dB into 50 Ohm***

A convenient point to examine the received RF signals after they have been amplified by the broadband section of the receiver.

The maximum voltage of this signal should not exceed 100 mV peak-to-peak.

**Note:** The level of amplification that may be measured at this monitor with respect to the signal fed into one of the RECEIVER INPUT [11-3](#) channels is about 32 dB less than the total receiver gain specified by the Gain [5-3](#) control.

## 11.2 Rear Panel

This section describes the instrument connectors that are located on the rear panel of the RAM-5000-SNAP.

- GA 1 PRE-GATE MON [11-4](#)
- GA 2 PRE-GATE MON [11-4](#)
- PHASE DET. NO.1 MON. [11-5](#)
- PHASE DET. NO.2 MON. [11-5](#)
- INTEGRATOR NO.1 MON. [11-5](#)
- INTEGRATOR NO.2 MON. [11-5](#)
- INTEGRATOR GATE MON. [11-5](#)
- RECEIVER OUTPUT [11-6](#)
- TRIGGER OUT [11-6](#)
- TRIGGER IN [11-6](#)

### 11.2.1 GA 1 PRE-GATE MON

**Impedance: 150 Ohms**

Monitors the signal that turns on the high-power Gated Amplifier No.1. This signal starts before and ends after the actual RF burst. Because the "pre-gate" time is set to one microsecond, the pre-gate monitor should not show any jitter with respect to the coherent TRIGGER OUT [11-6](#).

This output monitor is typically used as an input gate for the Clamped Diplexer RCDX-2A.

### 11.2.2 GA 2 PRE-GATE MON

**Impedance: 150 Ohms**

Same as GA 1 PRE-GATE MON [11-4](#) but for Gated Amplifier No.2.



### 11.2.3 PHASE DET. NO.1 MON.

***-20 dB into high impedance***

To check character and amplitude of a phase detected signal.

An "in-phase" signal should not exceed 200 mV at this monitor point which corresponds to a 2 Volt signal within the system.

### 11.2.4 PHASE DET. NO.2 MON.

***-20 dB into high impedance***

Same as for No.1 , except 90 degrees out-of-phase.

### 11.2.5 INTEGRATOR NO.1 MON.

***-20 dB into high impedance***

Provides for observation of the integration wave form of the No.1 Gated Integrator.

The maximum value of this signal must not exceed 500 mV for an in-phase signal. (This corresponds to a 5 Volt signal within the RAM.) It should normally be set for a maximum of 400 mV to leave head room for DC offsets that may occur. In general, DC offsets do not affect measurement performance because they are rejected by the 180-degree phase flipping techniques used in the system. However, if very long integration gates along with fast integration rates are employed, it is possible for the integrators to ramp up or down to their power supply rails and thereby destroy the possibility of acquiring useful information. Hence, it is always essential to monitor the integrator outputs to be sure that such a condition has not been encountered.

### 11.2.6 INTEGRATOR NO.2 MON.

***-20 dB into high impedance***

Same as for No.1 , except 90 degrees out-of-phase.

### 11.2.7 INTEGRATOR GATE MON.

***Impedance: 50 Ohms***

To check position and width of integrator gate.

Gate width should be slightly wider (at the base line) than the width of the phase detected signal to be integrated.

### 11.2.8 RECEIVER OUTPUT

**Impedance: 50 Ohm**

Output for the receiver.

The maximum voltage of the output signal should not exceed 1 V peak-to-peak.

**Note:** The level of amplification at the RECEIVER OUTPUT with respect to the signal fed into one of the RECEIVER INPUT [11-3](#) channels is about 12 dB less than the total receiver gain specified by the Gain [5-3](#) control.

### 11.2.9 TRIGGER OUT

**Impedance: 50 Ohms**

Positive (5 V) trigger that is coherent with the RF tone burst from the gated amplifier.

### 11.2.10 TRIGGER IN

**Requires positive TTL**

The system may be triggered from an external source injected into this connector; from the internal rep. rate generator; or from the computer that should then be programmed to provide a trigger signal that is appropriate to the measurement program being used. The RF tone burst will not be coherent with a trigger from either an external source or the computer. In both these cases, a new trigger coherent with the RF tone burst will be generated in the timing module. This trigger is available also at the rear panel TRIGGER OUT [11-6](#) connector.

# Section 12

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*System Checks*

## 12 System Checks

Several internal system diagnostic procedures may be initiated from the System Checks control panel to verify that the RAM-5000-SNAP is working properly.

For example, to check communication with the RAM-5000-SNAP, you can view the power supply voltages in the instrument by selecting the tab labeled "Power Supply Voltages".

- Power Supply Voltages  12-21

### 12.1 Power Supply Voltages

Pressing the button labeled "Check" will initiate an internal diagnostics procedure to produce voltage readings for the various power supplies.





# **Section 13**

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*Appendices*

## 13 Appendices

Some of the documentation is available in PDF format. You must have Adobe Reader 5.0.5 or later installed to view the PDFs.

- [Caution for Transducers](#)  [13-31](#)
- [Installation of the Computer Interface Board](#) (click to open or see *APPENDIX\_D.pdf*)
- [Installation of the “SealO” driver software in Windows 8.1](#) (click to open or see *SealO\_InstallStepsWin81.pdf*)
- [Installation of the “SealO” driver software in Windows 10](#) (click to open or see *SealO\_InstallStepsWin10.pdf*)
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### **Application Notes:**

- [SNAP System](#) (click to open or see *SNAP\_Info.pdf*)

## 13.1 Caution for Transducers

**CAUTION!!! EXERCISE GREAT CARE WHEN USING HIGH POWER PULSERS WITH CERAMIC TRANSDUCERS.**

The high voltage, high duty cycles pulses available from the low and medium frequency gated amplifiers may make it necessary to use modifications of standard, commercial transducers.

Experience has shown that those transducers with built in resonating inductors are most prone to failure either because of overheating of the coils or voltage breakdown to the case. Special transducers with at least a 1000 volt rating should be used if possible. In addition if impedance matching techniques are to be employed, even higher voltage ratings will be required. a method for removing heat from the transducers assembly may be required if operation at very high duty cycles is expected.

## 13.2 Controlling the RAM-5000-SNAP via USB

**Note:** This section assumes that the RAM-5000-SNAP is configured for operation with the Sealevel 8010 computer interface module. For the computer interface used by your particular RAM-5000 system refer to the **Specifications** in the Appendices [13-2].

With certain limitations, you can control and acquire data with the RAM-5000-SNAP also through a USB connection. This section describes how to connect to and operate the RAM-5000-SNAP via USB.

Although the RAM-5000-SNAP does not have a built-in USB port, a USB port can be emulated externally by using the *USB to 32 Channel TTL Digital Interface Adapter* from Sealevel. The Sealevel 8126 USB adapter module converts the 32-channel parallel data flow into a serial data flow, and vice versa, for communication via the USB standard.

The Sealevel 8126 can be used with the RAM-5000-SNAP User Interface version 1.0.96 and higher, which automatically detects the presence of the adapter module and reconfigures the RAM-5000 I/O driver accordingly.

For the most part, controlling the RAM-5000-SNAP through the Sealevel 8126 USB module will be transparent to the user and there are no noticeable performance limitations, other than a lower data acquisition speed.

Because serial communication is inherently slower than parallel communication, especially when frequently switching back and forth between input and output over a single data line, there are limitations to the achievable burst trigger repetition rates when acquiring data. That means, when acquiring data with the RAM-5000-SNAP through the Sealevel 8126 USB module, the effective burst trigger repetition rate may be much lower than is programmed as indicated in the user interface.

Depending on the chosen data acquisition settings, the actually achievable burst trigger repetition rate is often only 20 to 25 bursts/acquisitions per second. If much higher and more robust trigger rates are needed then you must use the Sealevel 8010 interface for controlling the RAM-5000-SNAP. You can verify the effective trigger rate by inspecting the timestamps in a data log file, taking into account your various acquisition settings.

### ***How to set up RAM-5000-SNAP instrument control over a USB connection:***

1. Install the Sealevel SeaMAX software drivers on the RAM-5000-SNAP control computer.
2. If applicable, unplug the ribbon cable that connects to the control computer. - There is no need to remove the Sealevel 8010 PCI card interface from inside the computer, nor to unplug the ribbon cable from the 8010 interface. Simply unplug the ribbon cable from the RAM-5000-SNAP.
3. Connect the Sealevel 8126 USB module to the RAM-5000-SNAP using a 50-conductor ribbon cable similar to the one supplied with the 8010.
4. Connect the Sealevel 8126 USB module to the control computer using a USB device



cable.

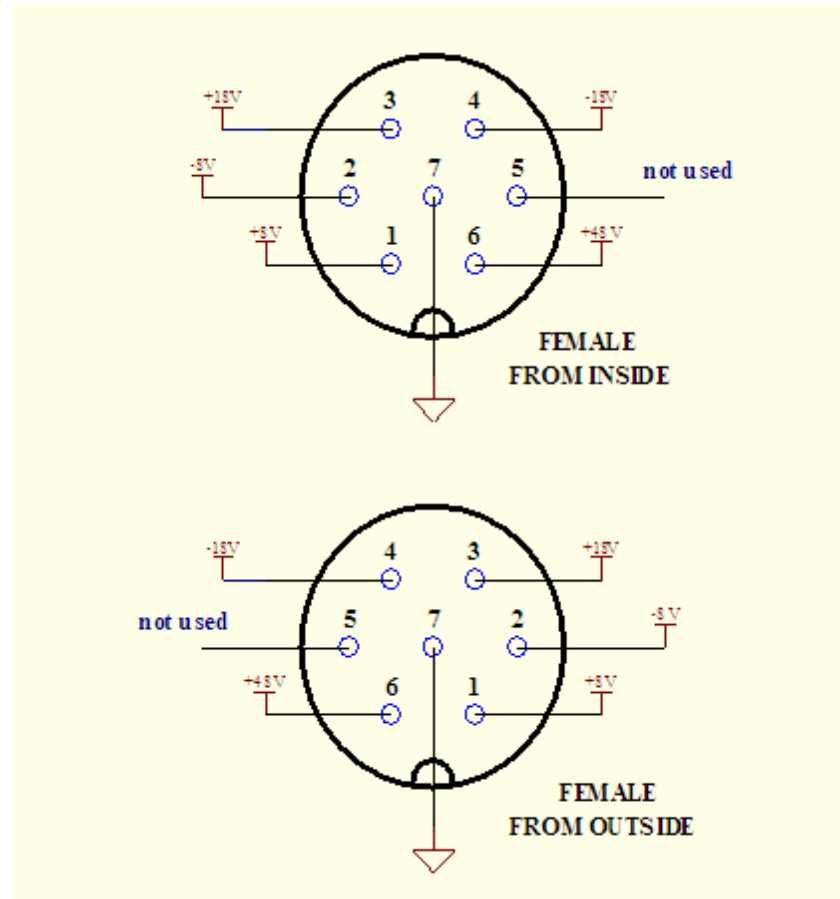
5. Verify that the 8126 is detected as such by the operating system. - Open the Device Manager and look for Sealevel 8126.
6. Launch the RAM-5000-SNAP User Interface as you normally would. - If the RAM-5000-SNAP User Interface successfully initialized I/O via the USB connection, the title bar will read "RAM-5000-SNAP (USB)".

***How to disable an existing USB connection:***

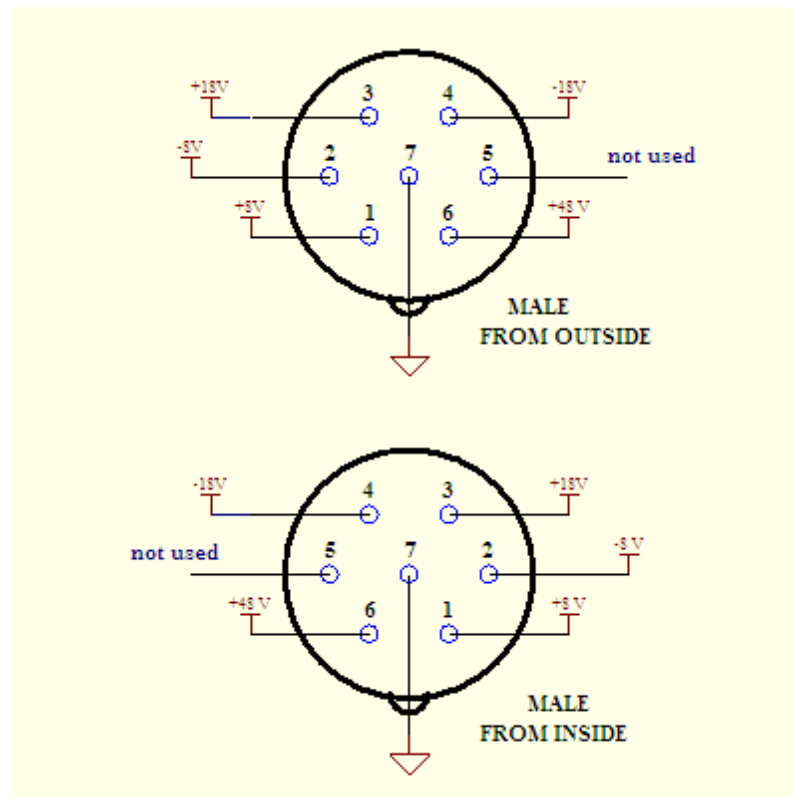
1. If applicable, shut down the RAM-5000-SNAP User Interface as you normally would.
2. Unplug either end of the USB device cable that connects the Sealevel 8126 USB module to the control computer.
3. Unplug the ribbon cable from the RAM-5000-SNAP that connects to the Sealevel 8126 USB module.
4. Insert the ribbon cable coming from the Sealevel 8010 interface inside the control computer into the RAM-5000-SNAP.
5. Launch the RAM-5000-SNAP User Interface as you normally would. - If the RAM-5000-SNAP User Interface successfully initialized I/O via the 8010 interface, the title bar will not show anything in parentheses.

### 13.3 External Power Output Connectors

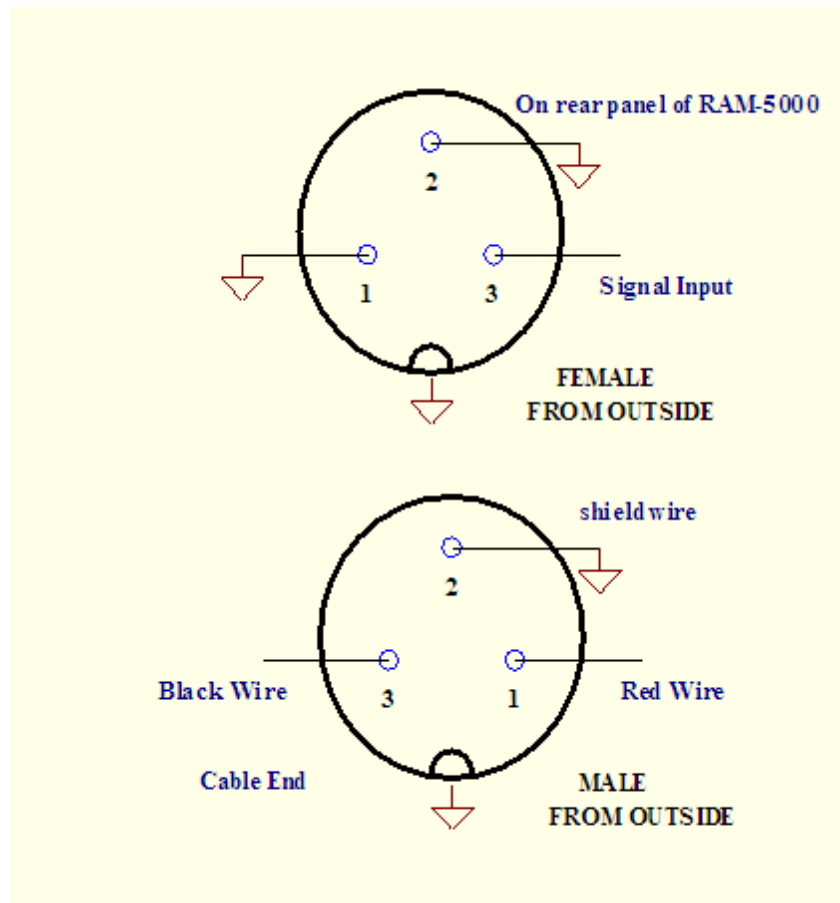
There is a pair of auxiliary power connectors located on the rear panel of the RAM-5000 instrument to power peripherals such as a clamped diplexer or preamplifier. For safety reasons, the connectors on the instrument are female polarity. With a powered peripheral, we will supply a 7-pin connector with a male/female end. The preamplifiers and clamped diplexers have both a male and female connectors so that more than one peripheral can be powered at once. The female connectors on the rear panel are connected as shown in the figure shown below:



The male connectors on the end of the power cable and the preamplifiers and clamped diplexers are shown as follows:



There are also two “External Sensor” input connectors on the rear panel of the RAM-5000 power frame. These are provided to allow measurements of thermocouple voltages, thermometer outputs, pressure sensors, etc. simultaneously with measurements of the acoustic properties such as attenuation and phase velocity. The connections are shown below:



## 13.4 Warranty

All RITEC instruments are warranted against defects in material and workmanship for a period of one year after date of original shipment. RITEC agrees to repair or replace any assembly or component found to be defective after normal use during this period. RITEC's obligation under this warranty is limited solely to repairing any such instrument that, in RITEC's sole opinion, proves to be defective within the scope of the warranty when returned to the factory. Transportation to the factory is to be prepaid by the purchaser. Shipment should not be made without prior authorization by RITEC. Please contact the factory for a return merchandise authorization (RMA) number.

This warranty does not apply to any products repaired or altered by persons not authorized by RITEC, or not in accordance with instructions furnished by RITEC. If the instrument is defective because of misuse, improper repair, or abnormal conditions or operations, repairs will be billed at cost.

RITEC assumes no responsibility for its product being used in a hazardous or dangerous manner either alone or in conjunction with other equipment. High voltage used in some instruments may be dangerous if misused. Special disclaimers apply to these instruments. RITEC assumes no liability for secondary charges or consequential damages and, in any event, RITEC's liability for breach of warranty under any contract or otherwise shall not exceed the purchase price of the specific instrument shipped and against which a claim is made.

Any recommendations made by RITEC for use of its products are based upon tests believed to be reliable, but RITEC makes no warranty of the results to be obtained. This warranty is in lieu of all other warranties, expressed or implied, and no representative or person is authorized to represent or assume for RITEC any liability in conjunction with the sale of our products other than set forth herein.

This warranty covers only items manufactured by RITEC. It specifically excludes all items sold by RITEC that were manufactured by other companies. All of these items are subject to their original individual manufacturer's warranty. Any claims for defective merchandise should be made to the original manufacturer for these items.

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