



# **Advanced Measurement System**

## **RAM-5000-M6-Plus**

### ***User Guide***

Version 1.1.11 Rev.0

# Table of Contents

<b>Section 1 Instrument Overview</b>	<b>1-2</b>
1 Introduction.....	1-2
2 Brief Description of Operation.....	1-3
3 Control and Data Acquisition.....	1-4
<b>Section 2 Getting Started</b>	<b>2-2</b>
1 Step-by-Step Installation Procedure.....	2-2
2 Preliminary Measurement Setup.....	2-3
<b>Section 3 User Interface</b>	<b>3-2</b>
1 Overview.....	3-2
2 Main Menu.....	3-3
1 File Menu .....	3-4
2 Measurements Menu .....	3-5
3 Tools Menu .....	3-6
4 Options Menu .....	3-7
5 Window Menu .....	3-8
6 Help Menu .....	3-9
3 Setting Preferences.....	3-10
1 User Interface Preferences .....	3-10
Keyboard Shortcuts.....	3-12
2 General Preferences .....	3-15
4 Controlling Instrument Parameters.....	3-16
1 Menu Controls .....	3-16
2 Numeric Controls .....	3-17
3 Step Size Control .....	3-17
Manually Setting.....	3-18
Smart Auto-Sizing.....	3-18
<b>Section 4 Signal Generation</b>	<b>4-2</b>
1 Synthesizer.....	4-2
1 Frequency .....	4-3
2 Burst Width .....	4-3
Width Mode .....	4-4
3 Burst Delay .....	4-5
4 Phase .....	4-5
5 Amplitude .....	4-6
2 Gated Amplifier.....	4-6
1 Output Control .....	4-7
2 Output Level .....	4-7
3 RF Level Control .....	4-8
4 Bias Control .....	4-9

<b>3 Output Enable</b> .....	<b>4-9</b>
<b>4 Modulator</b> .....	<b>4-10</b>
<b>1 Modulation Type</b> .....	<b>4-12</b>
Combine Operation.....	4-17
Hanning Operation.....	4-18
Modulation Dialog.....	4-19
<b>2 Amplitude Control</b> .....	<b>4-23</b>
<b>3 Ratio of Amplitudes</b> .....	<b>4-23</b>
<b>4 DC Offset Control</b> .....	<b>4-24</b>
Calibration .....	4-25
<b>5 Trigger</b> .....	<b>4-27</b>
<b>1 Trigger Source</b> .....	<b>4-28</b>
<b>2 Manual Trigger</b> .....	<b>4-29</b>
<b>3 Burst Rep-Rate</b> .....	<b>4-29</b>
<b>4 External Trigger</b> .....	<b>4-30</b>

## **Section 5 Signal Detection 5-2**

<b>1 Receiver Input</b> .....	<b>5-3</b>
<b>1 Input Enable</b> .....	<b>5-3</b>
<b>2 Input Channel</b> .....	<b>5-3</b>
<b>2 Receiver Amplifier</b> .....	<b>5-3</b>
<b>1 High-Pass Filter</b> .....	<b>5-3</b>
<b>2 Low-Pass Filter</b> .....	<b>5-4</b>
<b>3 Gain</b> .....	<b>5-4</b>
<b>3 Superheterodyne Detector</b> .....	<b>5-5</b>
<b>1 Frequency</b> .....	<b>5-5</b>
<b>2 Tracking</b> .....	<b>5-6</b>
Source Control .....	5-6
Frequency Component.....	5-7
<b>3 Phase</b> .....	<b>5-8</b>
<b>4 IF Bandwidth</b> .....	<b>5-8</b>
<b>5 Video Low-Pass Filter</b> .....	<b>5-8</b>
<b>4 Gated Integrators</b> .....	<b>5-9</b>
<b>1 Gate Delay</b> .....	<b>5-9</b>
<b>2 Gate Width</b> .....	<b>5-9</b>
<b>3 Integration Rate</b> .....	<b>5-9</b>
<b>5 FFT Detector</b> .....	<b>5-10</b>
<b>1 Waveform Windowing</b> .....	<b>5-10</b>
<b>2 Waveform Gating</b> .....	<b>5-11</b>
<b>3 FFT Resolution Enhancement</b> .....	<b>5-11</b>
<b>4 Spectrum Analyzer Preview</b> .....	<b>5-12</b>
<b>5 Frequency</b> .....	<b>5-12</b>
<b>6 Tracking</b> .....	<b>5-13</b>
Source Control.....	5-13
Frequency Component.....	5-14
<b>6 Waveform Digitizer</b> .....	<b>5-15</b>
<b>1 Vertical</b> .....	<b>5-16</b>
<b>2 Horizontal</b> .....	<b>5-16</b>
<b>3 Trigger</b> .....	<b>5-16</b>
<b>4 Signal Conditioning</b> .....	<b>5-17</b>

<b>Section 6 Data Acquisition</b>	<b>6-2</b>
1 Overview.....	6-2
2 Acquisition Control Panel.....	6-3
1 Trigger .....	6-4
Trigger Source .....	6-4
Burst Rep-Rate .....	6-5
External Trigger.....	6-6
2 Data Logging .....	6-6
Log File Format .....	6-7
3 Scanning .....	6-8
Scan Type .....	6-8
Source/Receiver.....	6-12
Range Parameters.....	6-13
Scan Data Files.....	6-14
4 Background .....	6-15
Background Setup.....	6-17
5 Run Mode .....	6-20
Burst Counter .....	6-22
RUN/START .....	6-22
3 Acquisition Options.....	6-23
1 Acquisition Mode .....	6-24
Quadrature Mode.....	6-25
Reference Phase.....	6-25
FFT Oscilloscope Channel.....	6-26
FFT Data Scaling.....	6-26
2 Averaging .....	6-26
Mean Average.....	6-26
Weighted Running Average.....	6-27
3 Multi-Frequency Tracking .....	6-28
MFT Setup .....	6-29
4 Signal Sets .....	6-30
Set-To-Set Variables.....	6-31
Active Signal Set.....	6-32
Signal Acquisition State.....	6-33
5 Auxiliary A/D Channels .....	6-33
Auxiliary A/D Setup.....	6-34
<b>Section 7 Data Display</b>	<b>7-2</b>
1 Oscilloscope.....	7-3
2 Meters .....	7-5
1 The Digital Meter .....	7-6
2 Auxiliary Analog Display .....	7-6
3 The Analog Meter .....	7-6
4 Auxiliary Digital Display .....	7-7
3 Strip Charts.....	7-8
1 Number of Points .....	7-9
2 The Strip Chart .....	7-9
4 A versus B Graph.....	7-11
1 Number of Points .....	7-12
2 Aspect Ratio 1:1 .....	7-12

- 3 The AB Graph ..... 7-12
- 5 Table View ..... 7-15
  - 1 Number of Rows ..... 7-16
  - 2 The Table ..... 7-16
- 6 Scan Graph..... 7-18
  - 1 The XY Graph ..... 7-20
- 7 Common Display Controls..... 7-23
  - 1 Data Type ..... 7-23
  - 2 Tracking Frequency ..... 7-24
  - 3 Signal Set ..... 7-24
  - 4 Axis Properties ..... 7-25
  - 5 Graph Properties ..... 7-26

**Section 8 Making Measurements 8-2**

- 1 Overview..... 8-2
- 2 Time of Flight and Transit Time ..... 8-2
  - 1 Measuring Transit Time ..... 8-3
  - 2 Measurement Panel ..... 8-5
- 3 Relative Magnitude, Phase, Time, and Attenuation..... 8-6
  - 1 Measuring Changes in Transit Time and Attenuation ..... 8-6
  - 2 Measurement Setup ..... 8-8
- 4 Nonlinear Parameters..... 8-12
  - 1 Measuring Beta ..... 8-12
  - 2 Parameter Setup ..... 8-14

**Section 9 Add-on Modules 9-2**

- 1 Oscilloscope..... 9-2
  - 1 Overview ..... 9-3
  - 2 User Interface ..... 9-4
    - Overview ..... 9-4
    - Main Menu ..... 9-4
      - File ..... 9-5
      - Measurements..... 9-6
      - Tools ..... 9-6
      - Options ..... 9-6
      - Window ..... 9-7
      - Help ..... 9-7
    - Waveform Graph..... 9-8
    - Display Options ..... 9-8
    - Channel Selectors ..... 9-9
    - Controlling the Oscilloscope..... 9-10
      - Menu Controls ..... 9-10
      - Numeric Controls..... 9-11
  - 3 General Setup ..... 9-13
    - Input Signal Selector..... 9-13
    - Input Channels..... 9-13
    - RAM Gate Channel..... 9-13
  - 4 Vertical ..... 9-15
    - Sensitivity ..... 9-15
    - Variable Gain Mode..... 9-15

- Full Scale ..... 9-16
- Grid Labels ..... 9-16
- DC Offset ..... 9-17
- Channel Equalization Mode..... 9-17
- Input Coupling ..... 9-17
- 5 Horizontal ..... 9-18**
  - Timebase ..... 9-18
  - Variable Timebase Mode..... 9-19
  - Time Width ..... 9-19
  - Grid Labels ..... 9-20
  - Samples ..... 9-20
  - Fixed Sampling Rate Mode..... 9-21
  - Sampling Rate ..... 9-21
  - Zooming ..... 9-22
    - Magnify ..... 9-22
    - Position ..... 9-22
- 6 Trigger ..... 9-24**
  - Delay ..... 9-24
  - Source ..... 9-24
  - Trigger Type ..... 9-24
    - Edge Triggering..... 9-24
- 7 Acquisition ..... 9-26**
  - Averaging ..... 9-26
  - Filtering ..... 9-27
  - Run Controls ..... 9-28
  - More Options ..... 9-28
    - Sampling ..... 9-29
    - Filtering ..... 9-30
    - Streaming ..... 9-31
  - Maximizing Speed..... 9-32
- 8 Spectrum Analyzer ..... 9-34**
  - Analyzer Controls..... 9-34
  - Spectrum Graph..... 9-36
- 9 Storing Data ..... 9-38**
  - File Formats ..... 9-38
  - Streaming ..... 9-39
    - Stream File Analysis..... 9-40
      - File Opening ..... 9-40
      - Waveform Selection..... 9-41
      - Data Export ..... 9-42
    - Stream Data Export..... 9-42
      - File Naming ..... 9-42
      - Export Range..... 9-44
      - Output File Options..... 9-44
    - Exporting ..... 9-46
- 10 Measurements ..... 9-47**
  - Scalar-type ..... 9-47
  - Cursors ..... 9-48

**Section 10 Instrument API 10-2**

**Section 11 Theory of Operation 11-2**

**1 Signal Processing..... 11-2**

2	Superheterodyne Receiver and Phase-Sensitive Detector.....	11-3
3	Analog Integration.....	11-4
4	Reduction of Measurement Errors.....	11-7
<b>Section 12 Instrument Connectors</b>		<b>12-2</b>
1	Front Panel Connectors.....	12-2
1	RF BURST HIGH POWER OUT .....	12-2
2	RF BURST MONITOR .....	12-2
3	RECEIVER INPUT NO.1 .....	12-3
4	RECEIVER INPUT NO.2 .....	12-3
5	RECEIVER RF MONITOR .....	12-3
2	Rear Panel Connectors.....	12-3
1	SIGNAL OUT 1, 2, 3, 4 .....	12-4
2	TRIGGER OUT .....	12-8
3	TRIGGER IN .....	12-8
<b>Section 13 System Checks</b>		<b>13-2</b>
1	Power Supply Voltages.....	13-2
<b>Section 14 Appendices</b>		<b>14-2</b>
1	Caution for Transducers.....	14-3
2	Controlling the RAM-5000-M6-Plus via USB.....	14-4
3	External Power Output Connectors.....	14-6
4	Warranty.....	14-9
<b>Index</b>		

# Section 1

---

*Instrument Overview*



# 1 Instrument Overview

This chapter provides an overview of the RAM-5000-M6-Plus instrument.

- Introduction [1-2](#)
- Brief Description of Instrument Operation [1-3](#)
- Instrument Control and Data Acquisition [1-4](#)

## 1.1 Introduction

The RAM-5000-M6 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 1.5 kW RMS output power (up to 20 MHz at reduced power). The various transmitter parameters and functions under computer control are: the frequency sent to the gated amplifier, the number of RF cycles within the high power RF burst, the RF pulse power, the delay for the 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.

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

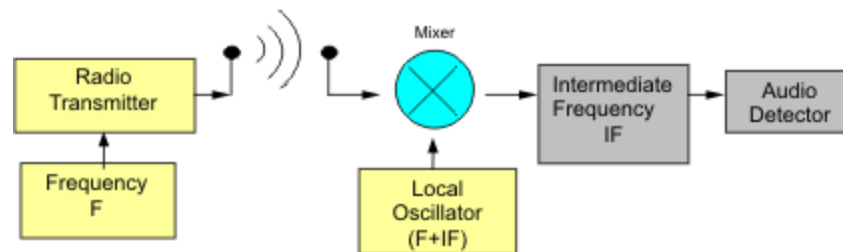
signals. Gated integrators then act on a selected signal, and the resultant DC voltages are recorded by the computer (via the interface card previously mentioned) for measurement purposes.

### ***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-M6-Plus 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-M6-Plus, 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-M6-Plus is controlled entirely from a computer running Microsoft® Windows® 7 or later. 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-M6-Plus may be programmed and operated from National Instruments LabVIEW™ via a control and data acquisition VI library.

# Section 2

---

*Getting Started*

## 2 Getting Started

This chapter describes details necessary to place the RAM-5000-M6-Plus system into operation.

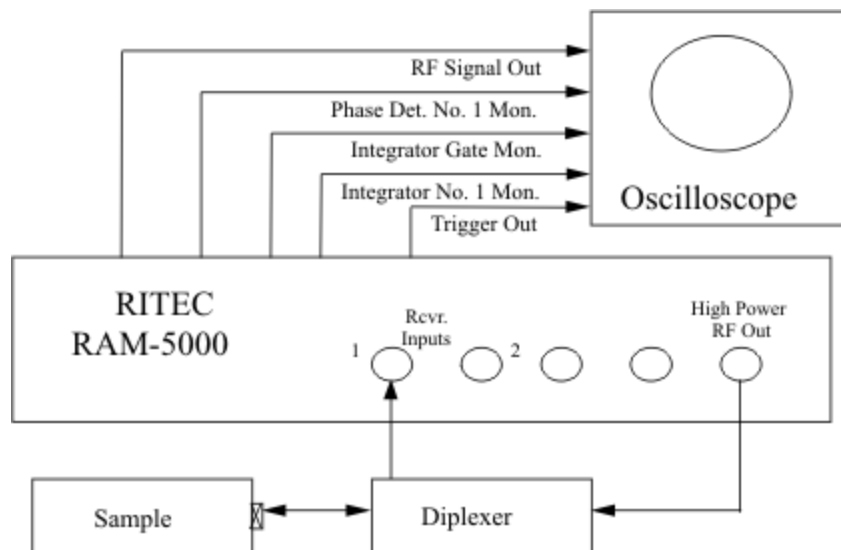


Figure 2-1. Typical RAM connection diagram.

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 [\[ 12-2 \]](#).

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-M6-Plus 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-M6-Plus.
3. BNC cable from "Trigger Out" (12-8) (rear of RAM) to Trigger In on oscilloscope.
4. BNC cable from "R.F. Pulse Monitor" (12-2) (front of RAM) to 50 Ohm input on oscilloscope.
5. BNC cable from "Phase Det. No.1 Mon." (rear of RAM) to second input on oscilloscope (high impedance).
6. BNC cable from the "High-Power RF Pulse Out" (12-2) 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" (12-3) 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" (12-2) or "RF Signal Out" (12-3), 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-M6-Plus and computer.
2. Start the software user interface already installed on the computer.

3. Program the RF Gain  $\left[ \begin{array}{c} \text{5-4} \\ \text{5-8} \end{array} \right]$  for approximately 40 dB (Receiver Setup).
4. Program the IF Bandwidth  $\left[ \begin{array}{c} \text{5-8} \\ \text{5-8} \end{array} \right]$  for 4 MHz (Receiver Setup).
5. Program the synthesizer for the desired operating frequency. (Source Setup)
6. Set the Gated Amplifier Output Level  $\left[ \begin{array}{c} \text{4-7} \\ \text{4-7} \end{array} \right]$  to 10 which will yield an output of approximately 144 Vpp. See calibration chart at the end of the RAM-5000-M6-Plus 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.

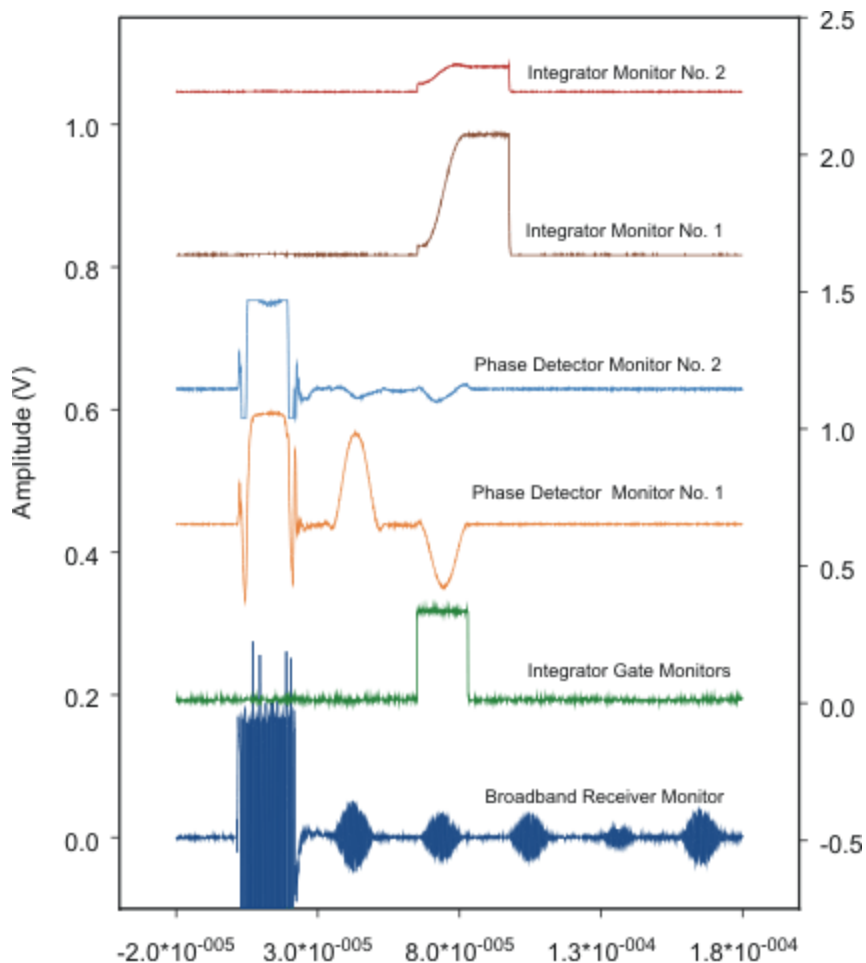


Figure 2-2. Receiver Monitors.

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.



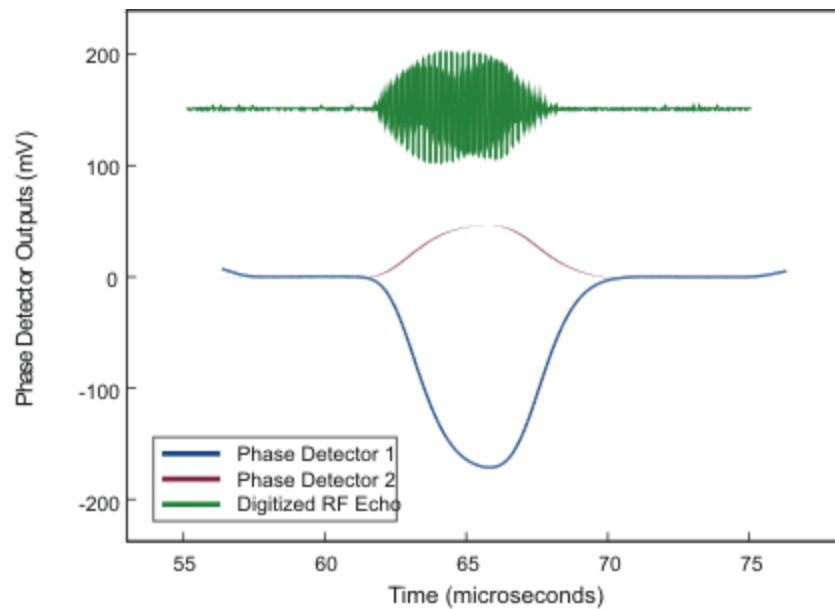


Figure 2-3. Typical Phase Sensitive Detector Output.

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.

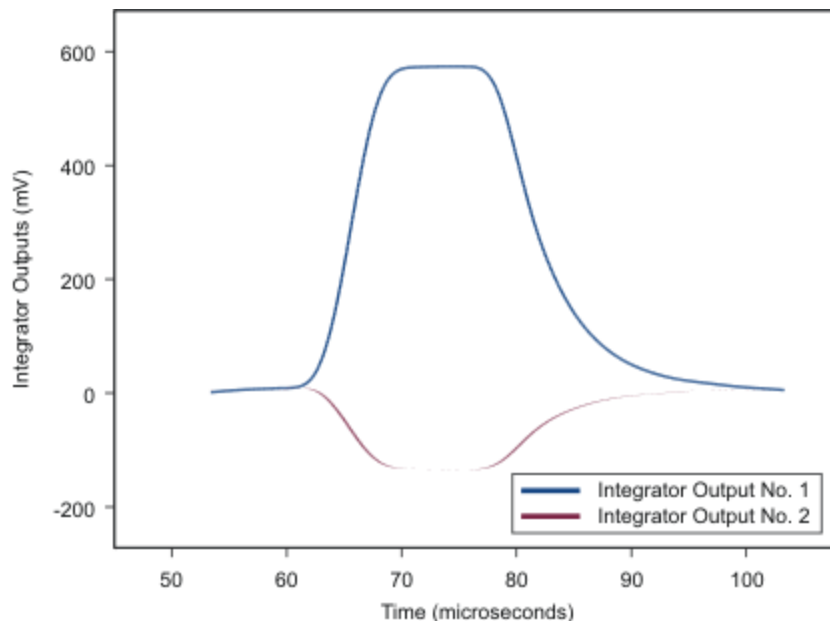


Figure 2-4. Typical Integrator Output.

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

---

*User Interface*

## 3 User Interface

This chapter provides an overview and describes general features of the software user interface to control the RAM-5000-M6-Plus instrument.

- Overview [3-2](#)
- Main Menu [3-3](#)
- Setting Preferences [3-10](#)
- Controlling Instrument Parameters [3-16](#)

### 3.1 Overview

The RAM-5000-M6-Plus is controlled entirely from a computer running Microsoft® Windows® 7 or higher. The controls of a traditional instrument front panel are emulated via a software user interface. The RAM-5000-M6-Plus user interface provides full control over all instrument operation parameters and features powerful data acquisition and sophisticated data display options.

**\*\*\* Picture of M6 UI needed \*\*\***

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-M6-Plus 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](#).

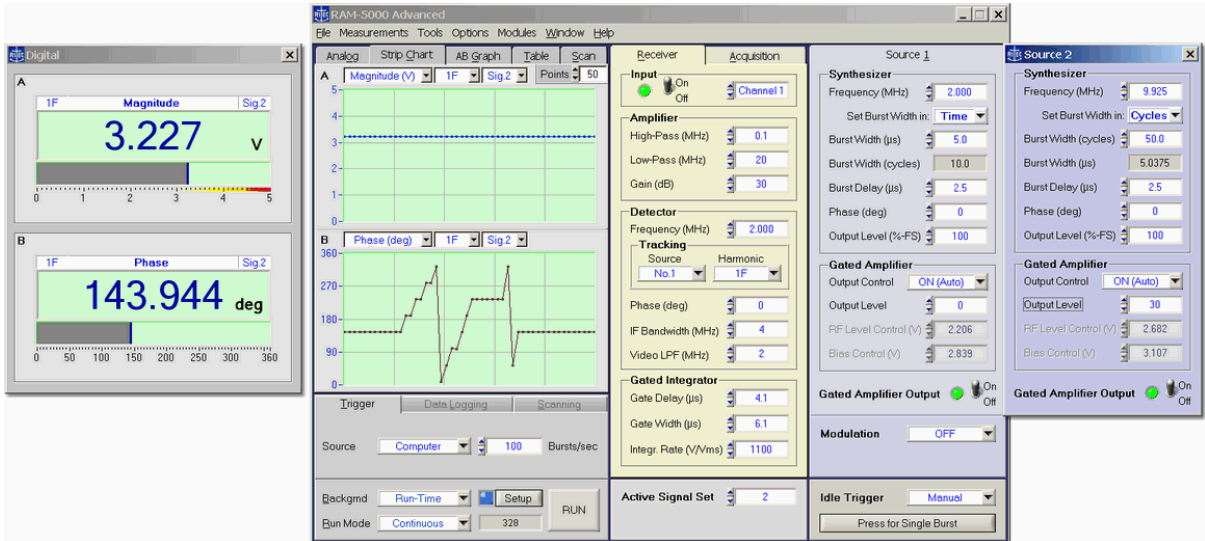
In the mid-section, there is a second pair of tabs, one with controls for the Receiver [5-2](#) and the other for setting various Acquisition Options [6-23](#).

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 Meter Gauges [7-5](#), a pair of synchronized Strip Charts [7-8](#), a Channel A versus Channel B Graph [7-11](#), a multi-purpose Data Table [7-15](#), as well as a Scan Graph [7-18](#) 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-M6-Plus user interface, as shown above, may also be customized to better suit your particular needs. For example, most of the tabs, may be detached from the main panel. To detach a tab and convert it into a freely movable separate window, right-click on the tab's label and select *Release* from the displayed context menu. To convert it back into a tab on the RAM-5000-M6-Plus user interface main window, simply close it. Whatever customization you may prefer, it is all saved and fully restored between sessions.



The RAM-5000-M6-Plus User Interface in one of many different customized layouts.

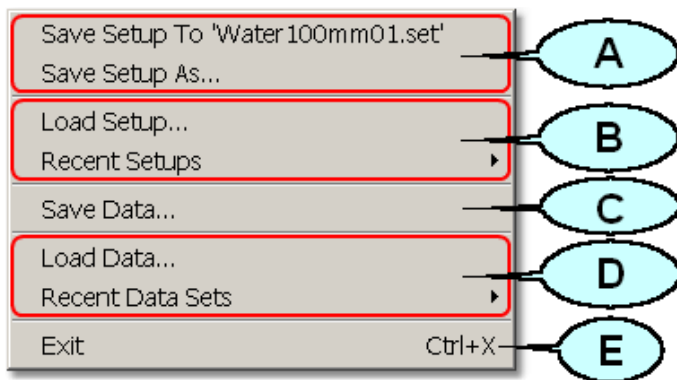
### 3.2 Main Menu



The main menu, located at the top of the RAM-5000-M6-Plus user interface, provides access to a series of named submenus. Each of these submenus are described individually:

- File <sup>3-4</sup>
- Measurements <sup>3-5</sup>
- Tools <sup>3-6</sup>
- Options <sup>3-7</sup>
- Window <sup>3-8</sup>
- Help <sup>3-9</sup>

### 3.2.1 File Menu



#### *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-M6-Plus 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 the most recent previously saved (and newly named) instrument setups for quick loading.

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

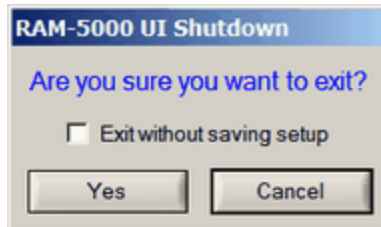
**Save Data...** opens a file/folder browser to save the current scan data to a specific folder and possibly under a new name.

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

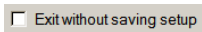
**Load Data...** opens a file/folder browser to load a previously acquired and saved data set from a specific folder.

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

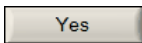
### Shutting down the RAM-5000-M6-Plus User Interface (E)



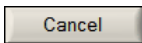
**Exit**, opens a confirmation prompt with the following options:




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-M6-Plus User Interface to reuse the settings that were last saved when exiting normally.



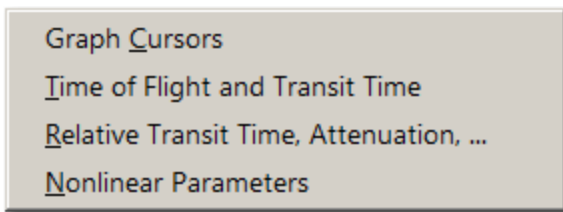
...proceed shutting down the User Interface. If the option "Exit without saving setup" was left in the unselected (default) state, the RAM-5000-M6-Plus User Interface automatically saves the current instrument setup and user interface settings before exiting.



...abort shutting down the User Interface.

**Note:** You can disable the confirmation prompt on the User Interface Preferences  dialog panel.

## 3.2.2 Measurements Menu



**Note:** The Measurements Menu will only be available if the RAM-5000-M6-Plus is equipped with the Mixer and IF, Phase Detector, and Gated Integrator modules.

This menu provides access to various types of measurements.

A 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 [7-23](#) 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.

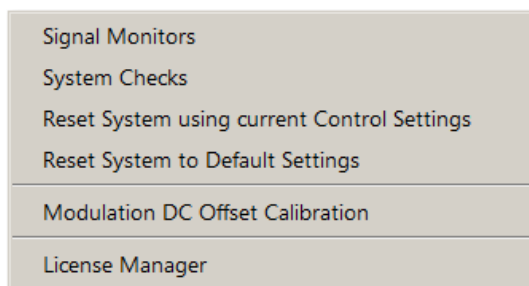
The measurements presently implemented, include:

- Time of Flight and Transit Time [8-2](#)
- Relative Transit Time, Attenuation, ... [8-6](#)
- Nonlinear Parameters [8-12](#)

**Note:** The measurements listed above are by no means representative of the full spectrum of measurement capabilities. In fact, a fully equipped RAM-5000-M6-Plus (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.

If you only wish to and perform simple measurements directly on a simple get a Also listed at the top of the measurements menu

### 3.2.3 Tools Menu



This menu provides access to various tools including the Signal Monitors configuration dialog [12-6](#) and a number of System Checks [13-2](#) that may be executed to verify that the RAM-5000-M6-Plus 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



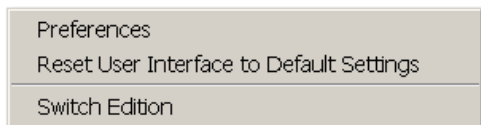
your system lost power while the RAM-5000-M6-Plus User Interface was still running, or when you are simply not sure about the current control programming state of the instrument.

**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 [3-7] 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 Menu

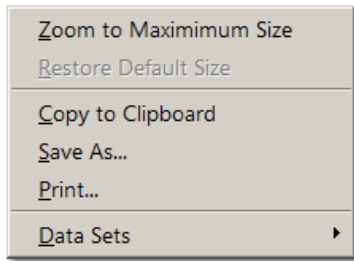


This menu includes a number of software configuration options. The item Preferences [3-10] opens up a dialog window for setting a number of options for the User Interface, data formats, etc.

From the Options Menu, you may also initiate a complete reset of the RAM-5000-M6-Plus 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 [3-7] 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 Menu

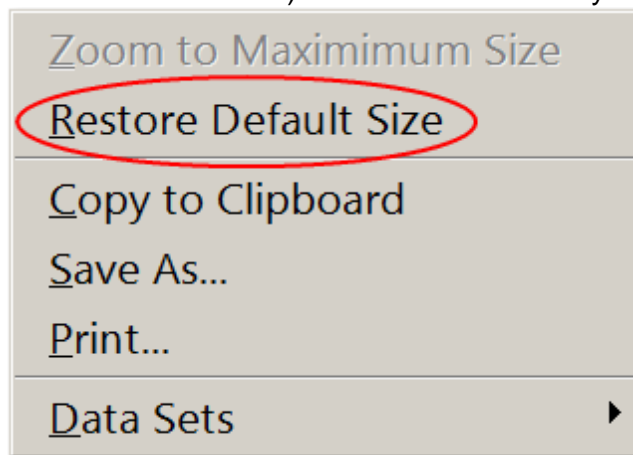


This menu contains items that control the size of the RAM-5000-M6-Plus user interface display. In addition, the Window Menu provides various options that allow you to create a bitmap image of the present display of the main window.

**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 [3-3](#) 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 its 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 (unless the User Interface has been reset [3-7](#)). 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:

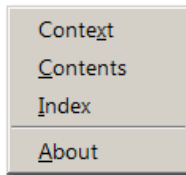
- \*.PNG --- PNG Bitmap (LZ77 Compression)
- \*.JPG --- JPEG Bitmap (90% Quality, Progressive/Interlaced)
- \*.TIF --- TIFF Bitmap (RLE Compression)
- \*.BMP --- Windows Bitmap (Uncompressed)

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.

**Data Sets** opens a submenu with a list of recently created copies of the Scan Graph (see ... [7-19] for details). The list of data sets that have been copied into new Scan Graph windows is only maintained within each particular RAM-5000-M6-Plus user interface session. Therefore, the Data Sets menu item is dimmed, if no additional scan data graphs exist at any given time.

### 3.2.6 Help Menu



The Help Menu provides access to various types of information related to the RAM-5000-M6-Plus hardware and the installed software components.

**Context** opens the RAM-5000-M6-Plus Help viewer with help specific to the control or panel that was last activated or selected.

**Contents** opens the RAM-5000-M6-Plus Help viewer with the Table of Contents (TOC) visible, the TOC tree collapsed, and shows the introductory help topic.

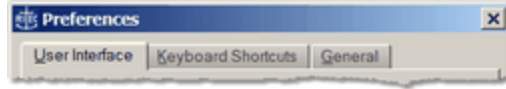
**Index** opens the RAM-5000-M6-Plus Help viewer with the Index visible, and shows the introductory help topic.

**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




In the RAM-5000-M6-Plus User Interface you can set several preferences that are related to the user interface, as well as to certain instrument control and data acquisition features.

The *Preferences* dialog box can be opened from the Options  menu. The *Preferences*



dialog box contains tabs , each for a different group of settings.

See the topics listed below to learn more about the various preferences that can be set.


- User Interface Preferences 
  - Keyboard Shortcuts 
- General Preferences 

The *OK*, *Cancel*, and *Help* buttons, located near the bottom of the *Preferences* dialog box, can be used as follows.

- **OK** — Accepts changes you made on any of the tab pages and closes the dialog box.
- **Cancel** — Discards changes you made on any of the tab pages and closes the dialog box.
- **Help** — Opens the help topic for the active tab page.

#### 3.3.1 User Interface Preferences

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-M6-Plus 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 window that belongs to the RAM-5000-M6-Plus User Interface within the visible region of the computer monitor screen. This includes detached tabs and any add-on module user interface windows.

Enable panel activation via mouse hover

Enabling this option makes each freely moving window that belongs to the RAM-5000-M6-Plus User Interface sensitive to mouse pointer movements. Each window that the mouse pointer moves over (hovers) will be immediately brought into the foreground and activated for user input. This includes detached tabs and any add-on module user interface windows.

Prompt for confirmation on exit

If this option is enabled (the default setting), the RAM-5000-M6-Plus User Interface will display a confirmation prompt before shutting down the instrument user interface [3-5](#). If this option is disabled, the software automatically saves the current instrument and user interface settings and then terminates execution without prompting you for confirmation. The next time you launch the User Interface all customized settings are reproduced.

Primary display style of Meters:  Analog  Digital

Setting this option determines the style of the measurement data display Meters. When this option is set to *Digital* (default setting), each meter uses a large numeric display, and when set to *Analog*, each meter resembles an analog gauge with a needle pointer.

Display phase data in 'degrees'

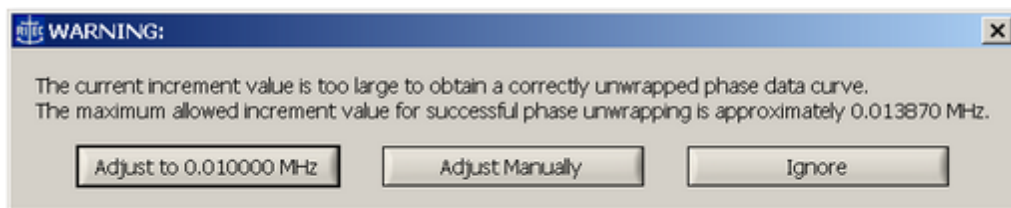
Enabling this option, the RAM-5000-M6-Plus User Interface always converts the phase data into degrees for display in any of the gauges (meters, charts, and the AB graph) as well as the scan graph. Regardless of how the phase data is being saved by the User Interface, you will always be able to view the 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-M6-Plus User Interface always tries to unwrap (by resolving  $2\pi$  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 [8-2](#) are to be performed.

Check scan frequency increment for phase unwrapping

If this option is enabled (the default setting), the RAM-5000-M6-Plus User Interface validates the frequency *Increment* value that you specify (maybe indirectly by specifying the *Points* value instead) on the Scanning [6-8](#) tab, when setting up a Frequency Scan. For successful phase unwrapping (resolving  $2\pi$  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.

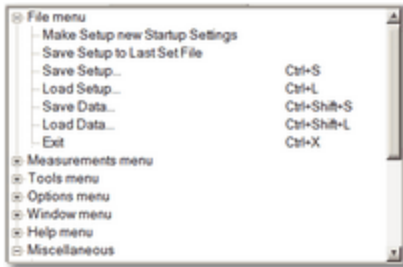
**Note:** The message dialog box shown above may also appear when starting a frequency scan and either the integrator gate settings or the detector frequency setting have been changed since specifying the frequency *Increment* value.

Prompt for filename at start of scan

If this option is enabled (the default setting), the RAM-5000-M6-Plus 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-M6-Plus software installation, even after exiting and restarting the User Interface.

### 3.3.1.1 Keyboard Shortcuts

Use the Keyboard Shortcuts tab to reassign or define new shortcut keys for the main menu and miscellaneous control actions in the RAM-5000-M6-Plus User Interface.



Lists applicable menu items and miscellaneous control actions and the currently assigned shortcut keys for each command.

**Note:** Any changes made to the shortcut key assignments are not committed to the RAM-5000-M6-Plus User Interface environment until you have closed the Preferences dialog box by clicking the *OK* button.

Right-click a menu or miscellaneous action item in the shortcuts list to access the context menu with these options.

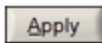
- **Find** - Searches through the shortcuts list for a specified string of text.
- **Expand All** - Shows all Menu and Miscellaneous subitems in the shortcuts list.
- **Collapse All** - Hides all Menu and Miscellaneous subitems in the shortcuts list.



**Modifier** allows you to select *None*, *Ctrl*, *Shift*, or *Ctrl+Shift* for extending the range of possible shortcut keys.




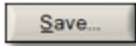
**Key** lists all the keys that are available for you to create shortcut key assignments with or without a **Modifier** key. Depending on the selected **Modifier**, you can select function keys, letter keys, various special keys, and for certain miscellaneous control actions also numeric keys.



Click the **Apply** button to assign the currently selected **Modifier** and **Key** combination as the shortcut for the highlighted menu or control command.

If you try to assign a shortcut that is already in use, a *Conflicting Shortcuts* message appears, which shows the command assigned to the shortcut you are attempting to use. On the *Conflicting Shortcuts* message box you can select "*Clear existing assignment and then assign shortcut to selected item*", which removes the currently assigned shortcut and accepts the new shortcut, or you can click "*Select a different shortcut*" to cancel the attempted shortcut assignment.

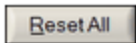
As a visual aid, the text label of the Apply button turns red  if the currently selected **Modifier** and **Key** combination is already in use.



**Save...** stores the currently assigned shortcuts in a user-named data file for reloading at a later time. Please note, the *currently assigned shortcuts* are the shortcut assignments as seen in the shortcuts list. These do not necessarily have to represent the shortcuts that are already committed for use, unless you opened the Preferences dialog and did not make any changes to the shortcut assignments before saving them.



**Load...** retrieves a previously saved set of shortcut assignments from a user-named data file and updates the shortcut list accordingly.



**Reset All** opens the *Keyboard Shortcuts List Reset* dialog box for setting the shortcut assignments back to an earlier state. The Reset All button may be dimmed, and any type of reset thus unavailable, if the shortcut assignments in the shortcuts list [3-13](#) represent the default settings and no other shortcut data is presently loaded.

The *Keyboard Shortcuts List Reset* dialog box may offer you up to three different options for resetting the current shortcut assignments.

- **Last Active** restores the shortcut assignments used just before opening the Preferences dialog. Thus, this option is available only if there are still uncommitted changes in shortcut assignments.
- **Last Loaded** restores the shortcut assignments loaded most recently, either automatically when starting the RAM-5000-M6-Plus User Interface or manually [3-14](#). This option is available only if the loaded data differs from the data in the shortcuts list [3-13](#).
- **Default** restores the default assignments. This option is available only if the default assignments differs from the assignments presently shown in the shortcuts list [3-13](#).

If none of the presented options in the *Keyboard Shortcuts List Reset* dialog box are what you would like to do you can cancel resetting the current shortcut assignments by clicking the [X], located in the upper right corner of the dialog box.



### 3.3.2 General Preferences

Save phase data in 'degrees'

Enabling this option, the RAM-5000-M6-Plus 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-M6-Plus 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 form.

Save standard deviation data

Enabling this option, the RAM-5000-M6-Plus 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>6-26</sup>.

**Note:** The *Save standard deviation data* option is unavailable (dimmed check box) and automatically disabled, whenever averaging is either disabled (Mode setting *OFF*) or when set to Mode *Weighted Running*. However, when this option is disabled automatically when being enabled, the setting is remembered and automatically restored upon changing the averaging mode back to *Mean*.

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,

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

and

$$\sigma_{Phase} = \frac{\sqrt{\left(\overline{V_{Integrator.No.2}} \cdot \sigma_{Integrator.No.1}\right)^2 + \left(\overline{V_{Integrator.No.1}} \cdot \sigma_{Integrator.No.2}\right)^2}}{\left(\overline{V_{Magnitude}}\right)^2},$$

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

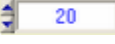

All instrument parameters can be controlled via *menu* or *numeric* user interface controls. A menu control [3-16](#) is used when the instrument parameter may be set to a limited number of specific options, such as filter settings. A numeric control [3-17](#) is used when the instrument parameter may 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 [3-17](#) 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. Thus, when you click on such a control, a popup menu will list the available options 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, 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 click on the control's text label, immediately after editing its value.

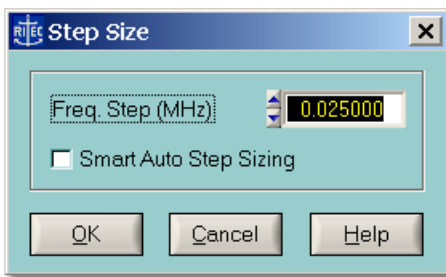
A pair of small arrow buttons located on the left side of the control, allows for stepping the numeric value up and down by a preset step size value. You may also change the value of a control by using the up and down arrow keys on the keyboard once the control has been activated.

**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 clicking on its label, 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-M6-Plus User Interface, or you may customize it. To customize use the step size control  dialog that is accessible by right-clicking 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-M6-Plus User Interface, based on control value keyboard input (see Smart Auto Step Sizing  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-M6-Plus 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 
- Smart Auto-Sizing 

### 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 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

---

*Signal Generation*

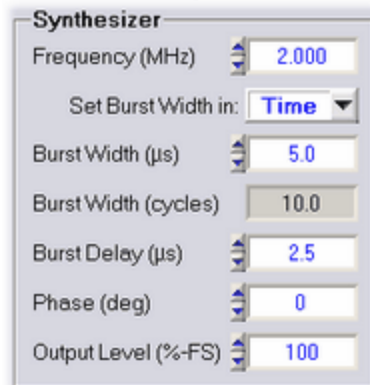
## 4 Signal Generation

This section describes the controls that are located on a Source tab and on the Trigger panel of the RAM-5000-M6-Plus User Interface.

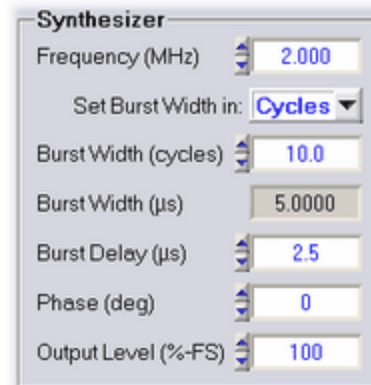
- Synthesizer [4-2](#) - Frequency, Burst Width and Delay, Phase, and Output Level
- Gated Amplifier [4-6](#) - Output Control and Level, RF Level and Bias Controls
- Output Enable [4-9](#)
- Modulator [4-10](#) - Modulation Type, Amplitude, and DC Offset
- Trigger [4-2](#) - Source Control and Rep-Rate

**Note:** Throughout the RAM-5000-M6-Plus 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-M6-Plus Pulse Source setup has the following control options:

- Frequency [4-3](#)
- Burst Width [4-3](#)
- Burst Delay [4-5](#)
- Phase [4-5](#)
- Output Level [4-6](#)

### 4.1.1 Frequency

**Nominal range:** 0.2 to 20 MHz in 1-Hz steps. For the range of your RAM-5000-M6-Plus refer to the **Specifications** in the Appendices [14-2](#).

This control [3-17](#) 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 [4-4](#).

When using modulation [4-12](#) 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-M6-Plus refer to the **Specifications** in the Appendices [14-2](#).

This control [3-17](#) is for setting the burst width. Depending on the set Burst Width Mode [4-4](#), 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 [4-3](#).

#### **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 (rounded to the nearest possible hardware setting), displayed in the numeric indicator immediately below, is automatically updated in accordance with the current Burst Frequency [4-3](#).

**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  $\left[ \begin{array}{c} 4-12 \\ \downarrow \end{array} \right]$  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  $\left[ \begin{array}{c} 4-5 \\ \downarrow \end{array} \right]$  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  $\left[ \begin{array}{c} 3-16 \\ \downarrow \end{array} \right]$  determines whether the Burst Width  $\left[ \begin{array}{c} 4-3 \\ \downarrow \end{array} \right]$  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 operating 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-M6-Plus refer to the **Specifications** in the Appendices [14-2](#).

This control [3-17](#) 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 [5-9](#) and width [5-9](#). The RAM-5000-M6-Plus 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 [3-17](#) 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)*

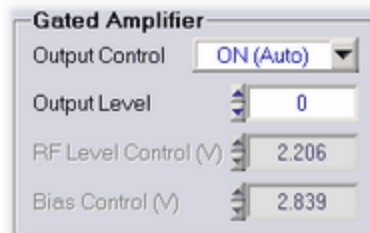
*Advanced Edition only*

This control [3-17](#) is for setting the output amplitude level of the synthesizer.

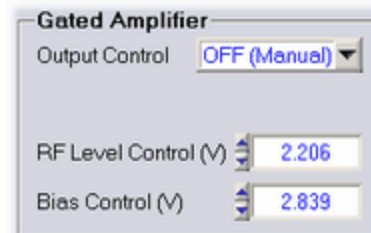
The synthesizer output level control provides an auxiliary method for setting the burst amplitude, which is done at the low-level stage of the signal source. The values always represent a percentage of the full scale (%-FS), where the maximum or full scale is determined by the present gated amplifier 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-M6-Plus Pulse Source setup has the following control options:

- Output Control [4-7](#)
- Output Level [4-7](#)
- RF Level Control [4-8](#)
- Bias Control [4-9](#)

## 4.2.1 Output Control

Standard settings: Manual, Auto, and Auto-Fine

This control  $\overline{3-16}$  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-M6-Plus 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  $\overline{4-7}$  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  $\overline{4-7}$  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  $\overline{3-17}$  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 and assuming the instrument is equipped with the 5-kW option (see **Specifications** in the Appendices  $\overline{14-2}$ ). 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-M6-Plus 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  $\overline{3-1}$  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-M6-Plus 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-M6-Plus 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-M6-Plus 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*

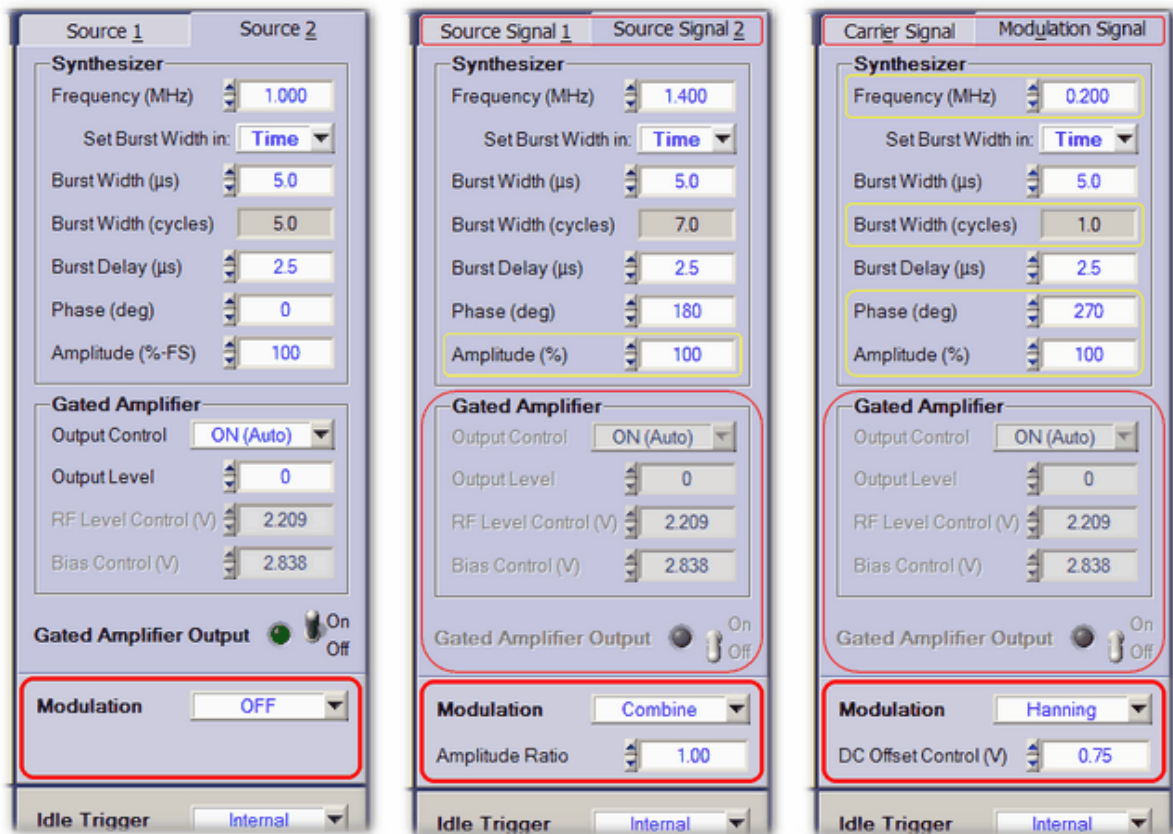
This toggle switch allows the specific gated amplifier to be made active or inactive in response to a trigger. In effect, this function disables or enables the output of the Pulse Source.

**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-M6-Plus hardware

front panel using the toggle switch, labeled HIGH VOLTAGE, which is located below the red LED.

## 4.4 Modulator

**Note:** This section assumes that the RAM-5000-M6-Plus is equipped with the Modulation module.







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-M6-Plus 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 
- Modulation Amplitudes 
- Ratio of Amplitudes 
- Modulation Signal DC Offset 

#### 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.



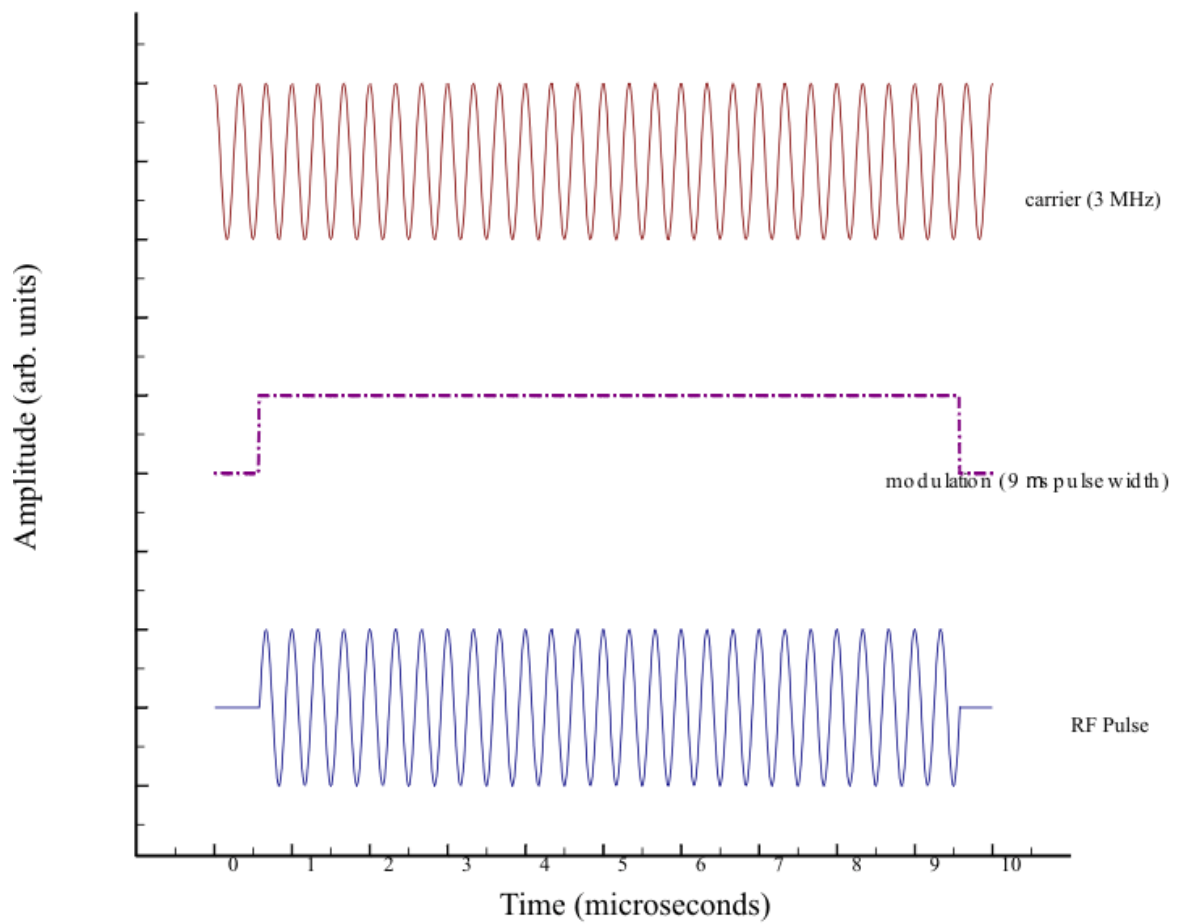


Figure 4-1. RF Pulse with Square Modulation.

To reduce the amplitudes of the frequency sidebands, two different modulation methods have been incorporated into the RAM-5000-M6-Plus 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.

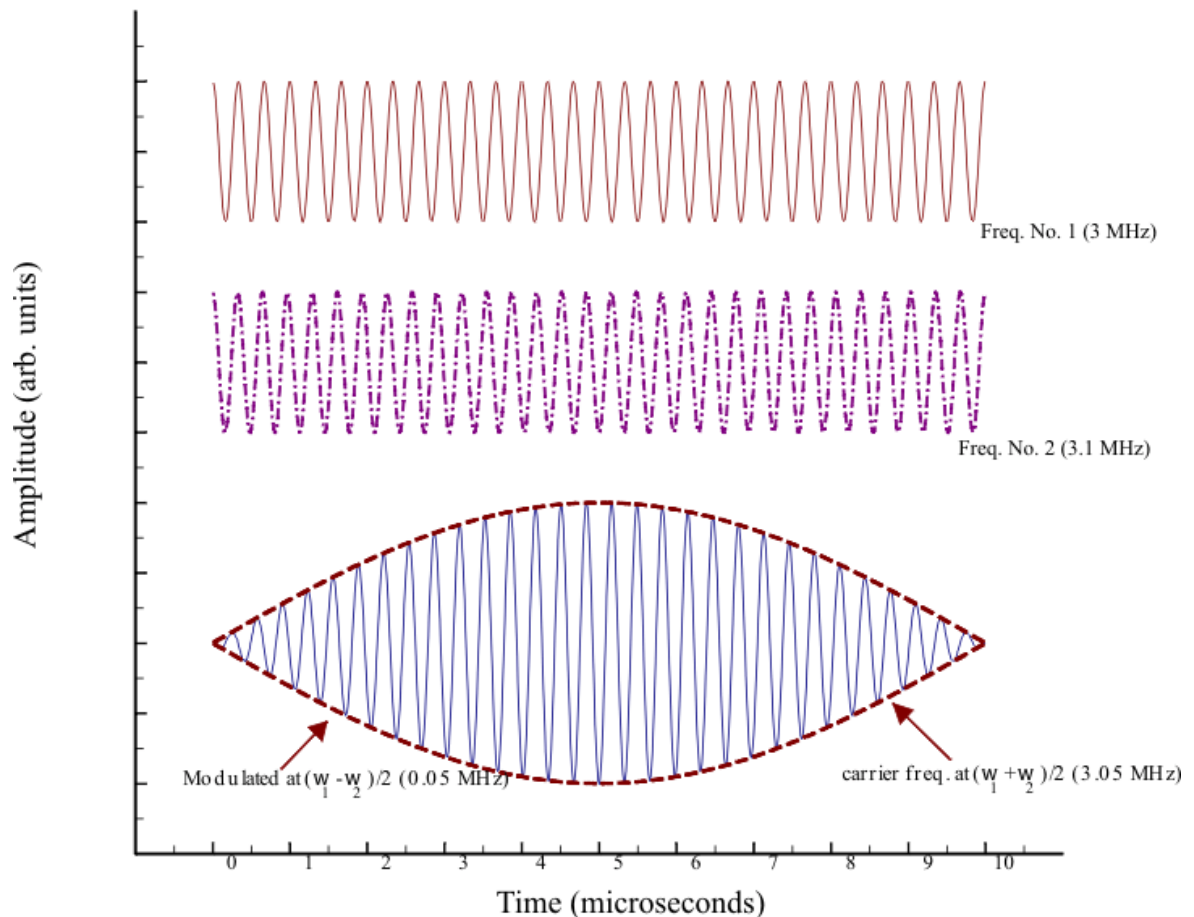


Figure 4-2. Combination of Two RF Frequencies.

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).

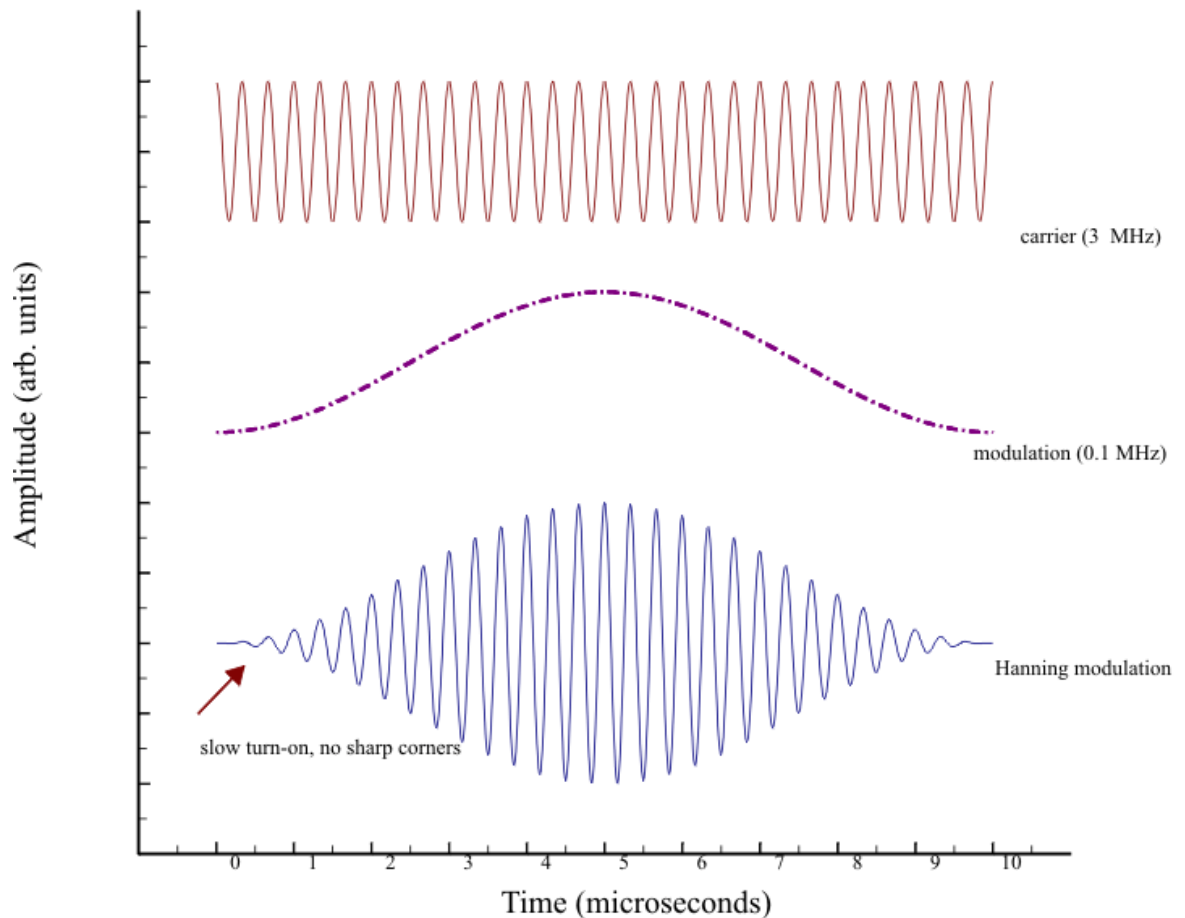


Figure 4-3. Hanning Modulation.

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

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-M6-Plus in the Combine modulation mode, various control settings of the Synthesizer [\[4-2\]](#) 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-M6-Plus 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 [\[4-12\]](#) 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 [\[4-19\]](#) 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 [\[4-4\]](#) 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 [7-20](#) 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-M6-Plus 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-M6-Plus User Interface and is updated when the burst width of the Carrier Signal changes.

Thus, the RAM-5000-M6-Plus 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):

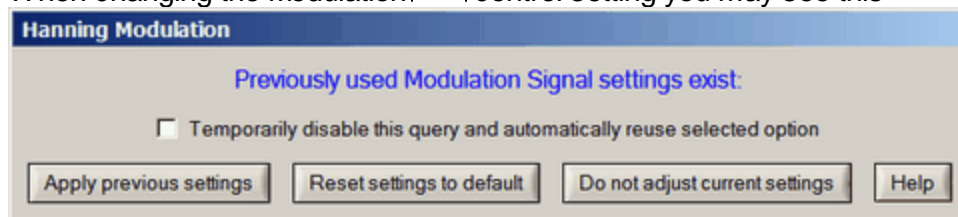
- Source 1: Phase = 0 degrees
- Source 2: Frequency = 1 / Burst Width of Carrier Signal (Source 1)  
 Phase = 270 degrees  
 Burst Delay and Width = Delay and Width of Carrier Signal  
 Amplitude = 100%  
 DC Offset = 0.75 V or 100% if calibrated <sup>4-25</sup>

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.

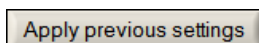
### 4.4.1.3 Modulation Dialog

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>4-27</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-M6-Plus 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-M6-Plus 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.

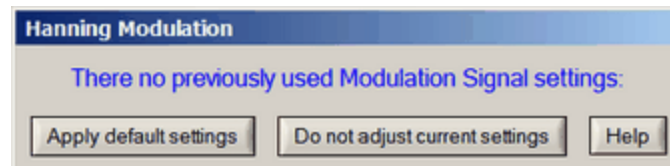
The RAM-5000-M6-Plus User Interface still verifies the validity of the selected action prior to committing to a new modulation type. If the selected action is found to be invalid for a particular switch, or because other instrument operation settings meanwhile have changed to invalidate this, the dialog 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?***

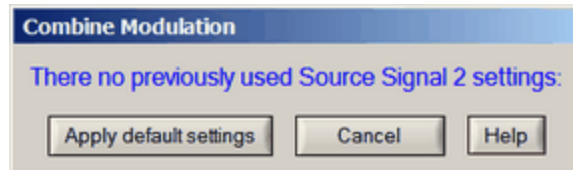
#### ***Selecting a different Modulation control setting for the first time***

When you select a different Modulation control setting for the first time, that is, since launching the RAM-5000-M6-Plus 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<sup>[4-20]</sup>" 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-M6-Plus 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.



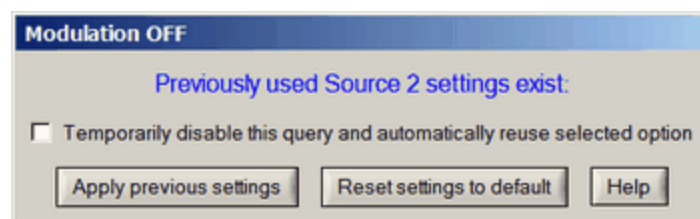
3. The Modulation control dialog when switching to Combine modulation for the first time, but the current Source 2 settings would not be valid for using through Source 1.

**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-M6-Plus 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-M6-Plus 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-M6-Plus 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 [3-17] 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 [3-17] 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 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 [3-17](#) 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-M6-Plus 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-M6-Plus User Interface. Thus, you can choose to calibrate the DC offset control from the Tools [3-6](#) 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  $270^\circ$  at a DC offset setting of +100%, and similarly for a phase setting of  $90^\circ$  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-M6-Plus 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-M6-Plus 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-M6-Plus 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-M6-Plus 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-M6-Plus 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 <sup>[4-18]</sup>.

**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.

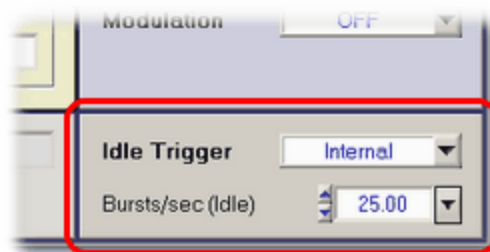
### Calibration Data:

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-M6-Plus 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>6-3</sup>.

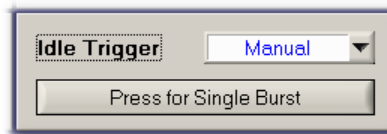
Depending on the selected **Trigger Source**, either a single burst may be triggered **Manually**, or a burst repetition rate (**Rep-Rate**) value may be specified for continuous triggering. If the Trigger Source is set to **External**, neither option will be available. More details on the various Trigger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

- Trigger Source <sup>4-28</sup>
- Manual Trigger <sup>4-29</sup>
- Burst Rep-Rate <sup>4-29</sup>
- External Trigger <sup>4-30</sup>

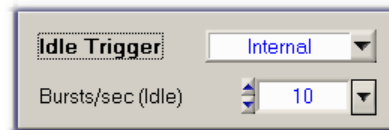
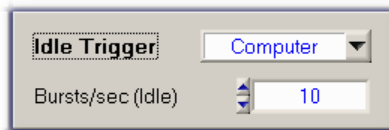
### 4.5.1 Trigger Source

*Standard settings: Manual, Computer, Internal, or External*

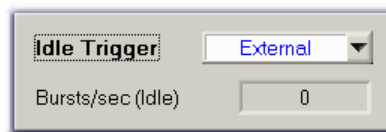
This control <sup>3-16</sup> is for setting the source of the *idle* trigger.



Setting the trigger source to **Manual** <sup>4-29</sup> 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 <sup>4-29</sup> 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 <sup>4-30</sup> 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-M6-Plus 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<sup>[12-8]</sup>" of the RAM-5000-M6-Plus 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<sup>[3-17]</sup> is for setting the idle (as opposed to data acquisition) burst rep-rate when the Trigger Source<sup>[4-28]</sup> 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-M6-Plus 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<sup>[4-28]</sup> control is set to any setting other than *Manual*, the rep-rate parameter needs to be chosen in conjunction with the Burst Width<sup>[4-3]</sup> and the gated

amplifier Output Level [4-7](#)) to insure a clear waveform presentation on the oscilloscope without exceeding the duty-cycle limitation of the RAM-5000-M6-Plus 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-M6-Plus 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 [12-2](#)) on the RAM-5000-M6-Plus front panel is not activated).

# Section 5

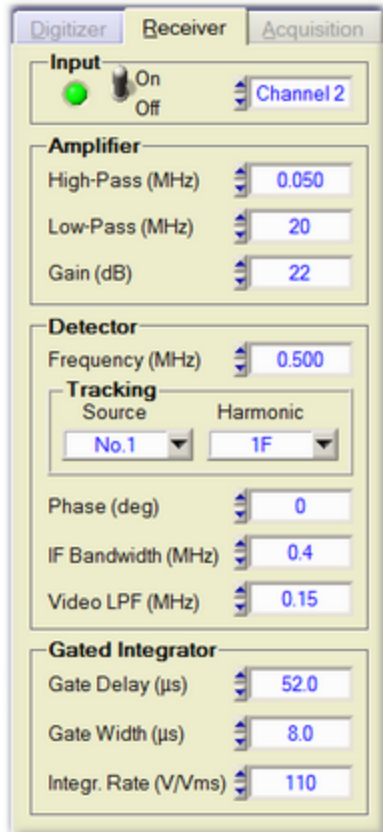
---

*Signal Detection*

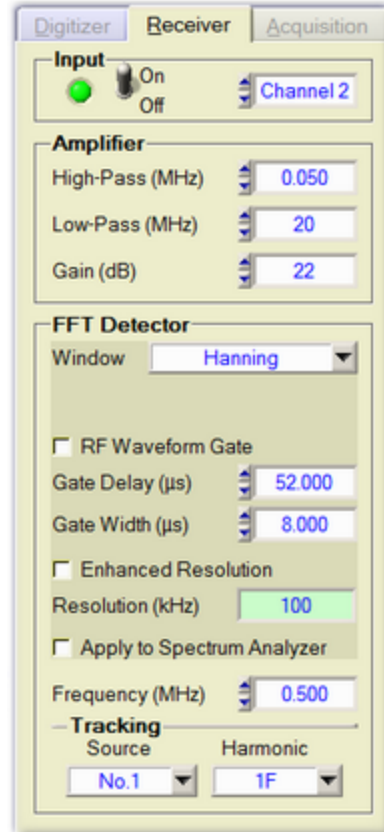
## 5 Signal Detection

This section describes the controls that are located on the Receiver tab and on the Digitizer tab of the RAM-5000-M6-Plus User Interface.

Depending on the active Acquisition Mode [6-24](#), the Receiver tab will look a little different in each case, as can be seen below. (If needed, please click on either picture to see an enlarged version of it.)



The Receiver tab when using the "Phase Sensitive" acquisition mode.



The Receiver tab when using the "Waveform FFT" acquisition mode.

The following topics describe the various components of the Receiver tab when in the *Phase Sensitive* acquisition mode.

- Input [5-3](#)
- Amplifier [5-3](#)
- Detector [5-5](#)
- Integrators [5-9](#)

The following topics describe the various components of the Receiver tab when in the *FFT Waveform* acquisition mode.

- Input [5-3](#)
- Amplifier [5-3](#)
- FFT Detector [5-10](#)

## 5.1 Receiver Input



*Receiver Input Controls*

The Input controls of the RAM-5000-M6-Plus Receiver setup are described below:

- Input Enable [5-3](#)
- Input Channel [5-3](#)

### 5.1.1 Input Enable

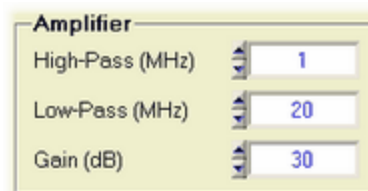
This toggle switch is for quickly disabling or enabling the input to the Receiver. This function is useful when performing oscilloscope or internal background signal diagnostics.

### 5.1.2 Input Channel

*Standard options:* Channel 1, and Channel 2. For the number of channels in your RAM-5000-M6-Plus refer to the **Specifications** in the Appendices [14-2](#).

This control [3-16](#) is for setting the active Receiver Input Channel.

## 5.2 Receiver Amplifier



*Receiver Amplifier Controls*

The Amplifier controls of the RAM-5000-M6-Plus Receiver setup are described below:

- High-Pass Filter [5-3](#)
- Low-Pass Filter [5-4](#)
- Gain [5-4](#)

### 5.2.1 High-Pass Filter

*Standard settings:* 0.25, 1, or 4 MHz. For the settings of your RAM-5000-M6-Plus refer to the **Specifications** in the Appendices [14-2](#).

This control [3-16](#) 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: 5, 10, or 20 MHz. For the settings of your RAM-5000-M6-Plus refer to the **Specifications** in the Appendices [14-2](#).*

This control [3-16](#) 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.

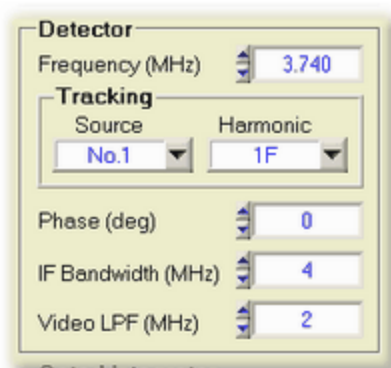
### 5.2.3 Gain

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

This control [3-17](#) 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 [12-3](#) (-20dB) point, while the same gain setting would result in 20-dB amplification between the RF input signal and the RECEIVER OUTPUT signal.

## 5.3 Superheterodyne Detector



*Heterodyne Detector Controls*

The superheterodyne (narrowband) detector controls of the RAM-5000-M6-Plus Receiver setup are described below:

- Frequency [5-5](#)
- Frequency Tracking [5-6](#)
- Phase [5-8](#)
- IF Bandwidth [5-8](#)
- Video Low-Pass Filter [5-8](#)

### 5.3.1 Frequency

*Nominal range:* 0.02 to 80 MHz in 1-Hz steps. For the range of your RAM-5000-M6-Plus refer to the **Specifications** in the Appendices [14-2](#).

This control [3-17](#) 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 [11-2](#), the actual frequency programmed into the synthesizer is the detector frequency plus 20 MHz.

**Note:** The remainder of this section assumes that the RAM-5000-M6-Plus is equipped with 2 Gated Amplifiers.

If the active receiver Tracking [5-6](#) 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 [6-28](#) 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 [5-6](#) 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 [5-7](#) setting. Conversely, if the receiver frequency is changed, the source frequency automatically updates accordingly.

Tracking may be set up for each *defined* signal set [6-30](#) individually, by first unlocking it and making it a set-to-set variable [6-31](#).

If Multi-Frequency Tracking [6-28](#) 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 [6-29](#) 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 [5-5](#) 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 [3-16](#) 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 [5-5](#) 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 [5-7](#) 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 [\[5-7\]](#) setting.

### 5.3.2.2 Frequency Component

*Standard options: 1F, 2F, 3F, 4F, 5F, SumF, or DifF (see Multi-Frequency Tracking [\[6-28\]](#) for advanced options)*

This control [\[3-16\]](#) 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 [\[6-28\]](#) 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 [\[6-29\]](#) 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-M6-Plus 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:

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

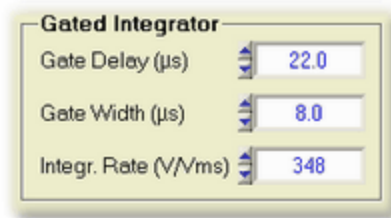
### 5.3.5 Video Low-Pass Filter

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-M6-Plus 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-M6-Plus Receiver setup are described below:

- Gate Delay <sup>5-9</sup>
- Gate Width <sup>5-9</sup>
- Integration Rate <sup>5-9</sup>

### 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-M6-Plus refer to the **Specifications** in the Appendices <sup>14-2</sup>.

This control <sup>3-17</sup> 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-M6-Plus refer to the **Specifications** in the Appendices <sup>14-2</sup>.

This control <sup>3-17</sup> 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

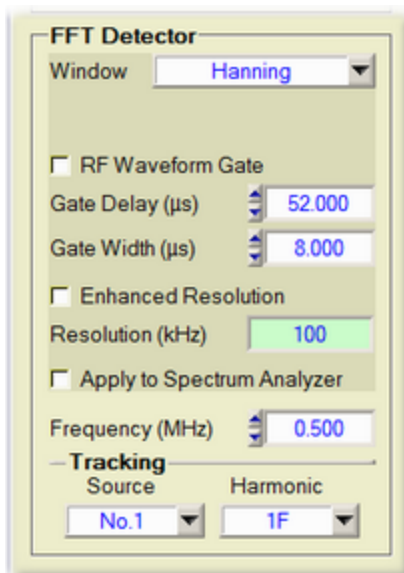
*Standard settings:* 0.454, 0.769, 1.36, 2.37, 4.12, 7.3, 12.2, 21.3, 37.0, 66.7, 110, 200, 350, 620, 1100, 2000 V/Vms. For the settings of your RAM-5000-M6-Plus refer to the **Specifications** in the Appendices <sup>14-2</sup>.

This control <sup>3-16</sup> is for setting the integration rate.

The integration rate refers to the  $r_I$  constant which appears in Equations 11-8 <sup>11-6</sup> and 11-9 <sup>11-6</sup>. 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.

## 5.5 FFT Detector



*FFT Detector controls*

The FFT Detector controls and options that are located on the RAM-5000-M6-Plus Receiver tab are described below:

- Waveform Windowing [5-10](#)
- Waveform Gating [5-11](#)
- FFT Resolution Enhancement [5-11](#)
- Spectrum Analyzer Preview [5-12](#)
- Detection Frequency [5-12](#)
- Frequency Tracking [5-13](#)

### 5.5.1 Waveform Windowing

The **Window** control allows you to apply a scaled window function to the waveform data before performing the FFT. If you have enabled RF Waveform Gating, the window function is applied not to the entire waveform shown in the Oscilloscope graph, but only to the gated portion of this waveform.

Applying a window function to a signal can be useful for accomplishing several processing and analysis operations. For example, when the waveform signal you want to analyze is poorly defined in time, a window helps to limit the duration of the signal of interest, which can

also reduce spectral leakage. Or, using the appropriate window can help to separate a small amplitude signal from a larger amplitude signal with frequencies very close to each other.

The following window functions are available:

- Hanning
- Hamming
- Blackman-Harris
- Exact Blackman
- Blackman
- Flat Top

The *Hanning* window is useful in a variety of applications, including general-purpose, or when the signal content is initially unknown. In particular, *Hanning* may be used when the signal consists of a sine wave or a combination of sine waves. The *Flat Top* window is typically used when accurate single-tone amplitude measurements are of interest. In cases where the signal consists of transients whose duration is shorter than the total acquisition length, it is generally best not to use any window, that is to use the *Window* control setting *OFF* (*Rectangle*). The same would apply when trying to separate two tones with frequencies very close to each other but with almost equal amplitudes. In general, you might need to experiment with different windows to find the best one for your application.

For a detailed description of the characteristics of these window functions and their use, please see the standard literature on digital signal processing.

### 5.5.2 Waveform Gating

Usually, you observe oscilloscope waveform traces that start before or extend far beyond a certain RF feature of interest, which you also might want to analyze regarding its frequency content. In other words, you seek a spectrum analysis of only a limited waveform section of the oscilloscope display. To do that you can apply a gate. To enable gating in the RAM-5000 Oscilloscope, click on the control labeled **RF Waveform Gating**.

When gating is enabled, you can specify the start and end time of the waveform section of interest using the **Gate Delay** and **Gate Width** controls, respectively.

**Note:** The entered "Gate Delay" and "Gate Width" control values may occasionally change slightly as you change certain oscilloscope timebase settings. In addition, the minimum and maximum values are equally dependent on the active timebase settings.

### 5.5.3 FFT Resolution Enhancement

To obtain a finer frequency resolution than is typically obtained based on the active oscilloscope timebase settings, you can enable the control labeled **Enhanced Resolution**.

When you enable Enhanced Resolution, the waveform data is automatically zero-padded before FFT processing.

When Enhanced Resolution is enabled, you can enter the desired frequency step size into the control labeled **Resolution (kHz)**.

When Enhanced Resolution is disabled, the **Resolution (kHz)** control functions as an indicator, displaying the current FFT Detector resolution based on the active oscilloscope timebase and the Detector's gating settings.

#### 5.5.4 Spectrum Analyzer Preview

Using the control, labeled **Apply to Spectrum Analyzer**, you can preview your FFT Detector settings in the Spectrum Analyzer graph. This is useful to observe the effects of a certain Window function in combination with RF Waveform Gating and/or the Enhanced Resolution setting before performing FFT Detector-based measurements.

#### 5.5.5 Frequency

*Nominal range:* Depends on bandwidth of RF receiver amplifier and digitizer, with variable step size based on active oscilloscope Timebase<sup>[9-18]</sup> and FFT Detector Enhanced Resolution<sup>[5-11]</sup> settings. For the bandwidth of your RAM-5000-M6-Plus RF receiver amplifier and digitizer refer to the **Specifications** in the Appendices<sup>[14-2]</sup>.

This control<sup>[3-17]</sup> is for setting the frequency at which a received signal is to be analyzed with the complex FFT detector.

**Note:** The detector frequency setting controls the frequency at which the amplitudes of the real and imaginary wave components are obtained from the FFT spectrum analyzer.

**Note:** The remainder of this section assumes that the RAM-5000-M6-Plus is equipped with 2 Gated Amplifiers.

If the active receiver Tracking<sup>[5-13]</sup> 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<sup>[6-28]</sup> or Modulation<sup>[4-10]</sup> ("lock" icon/button is not shown). The meaning of the detector frequency lock is as follows: In the unlocked state, you may adjust the detector frequency setting by changing either of the two source frequency settings. In the locked state, the detector 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<sup>[6-9]</sup>.

## 5.5.6 Tracking

This group of controls is for setting various FFT Detector Frequency Tracking options. If Tracking is enabled, that is for any Tracking Source<sup>[5-13]</sup> setting other than NONE, the detector frequency and the frequency of the selected Tracking Source are locked with respect to each other. That means, if the pulse source frequency is changed, the detector frequency automatically updates according to the Tracking Frequency<sup>[5-14]</sup> setting. Conversely, if the detector frequency is changed, the pulse source frequency automatically updates accordingly.

Tracking may be set up for each *defined* signal set<sup>[6-30]</sup> individually, by first unlocking it and making it a set-to-set variable<sup>[6-31]</sup>.

If Multi-Frequency Tracking<sup>[6-28]</sup> 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<sup>[6-29]</sup> 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<sup>[5-12]</sup> 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.

### 5.5.6.1 Source Control

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

This control<sup>[3-16]</sup> is for setting the FFT Detector Tracking Source synthesizer.

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

If the source control is set to **NONE**, tracking is disabled, and any detector frequency<sup>[5-12]</sup> 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 detector frequency setting is locked with respect to the operating frequency of Source 1 or Source 2, respectively, based on the Tracking Frequency<sup>[5-14]</sup> setting.

If the source control is set to **BOTH**, tracking is enabled, and the detector 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<sup>[5-14]</sup> setting.

### 5.5.6.2 Frequency Component

Standard options: 1F, 2F, 3F, 4F, 5F, SumF, or DiffF (see Multi-Frequency Tracking<sup>6-28</sup> for advanced options)

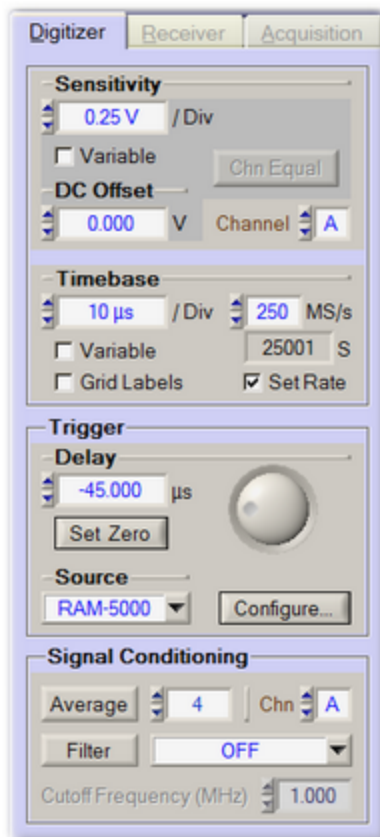
This control<sup>3-16</sup> is for setting the Tracking Frequency of the FFT Detector.

Control of the detector 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 detector frequency will "track" the frequency of Source 1, and cannot be changed independently. Attempts to change the detector frequency will also change the frequency of Source 1. (A 0.3 MHz change in the detector 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 detector frequency will be set to twice the frequency of Source 1, and cannot be changed independently. Attempts to change the detector frequency will result in changes to Source 1, but at one-half the magnitude. (A 0.3 MHz change in the detector frequency will result in a 0.15 MHz change in Source 1.)
3. If the tracking frequency is set to **3F**, the detector frequency will be set to three times the frequency of Source 1, and cannot be changed independently. Attempts to change the detector frequency will result in changes to Source 1, but at one-third the magnitude. (A 0.3 MHz change in the detector frequency will result in a 0.1 MHz change in Source 1.)
4. If the tracking frequency is set to **DiffF**, the detector 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 detector frequency cannot be changed independently.
5. If Multi-Frequency Tracking<sup>6-28</sup> is used, the detector 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<sup>6-29</sup> dialog.



## 5.6 Waveform Digitizer



*The Oscilloscope's digitization controls when confined to the RAM-5000 UI.*

When the Oscilloscope is confined to the RAM-5000-M6-Plus User Interface window, the oscilloscope's digitization controls are located on the *Digitizer* tab. That means, the *Digitizer* tab is not available when the entire Oscilloscope UI resides in its own application window.

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

- Vertical [5-16](#)
- Horizontal [5-16](#)
- Trigger [5-16](#)
- Signal Conditioning [5-17](#)

### 5.6.1 Vertical

This section describes the controls on the Digitizer tab that are used for adjusting the vertical waveform acquisition and display settings. These settings apply to the channel selected for editing. To set the edit channel, you use the Channel Selector [9-9](#).

- Sensitivity [9-15](#)
- Variable Gain Mode [9-15](#)
- Full Scale [9-16](#)
- DC Offset [9-17](#)
- Channel Equalization Mode [9-17](#)

### 5.6.2 Horizontal

This section describes the controls on the Digitizer tab that are used for adjusting the horizontal waveform acquisition and display settings. These settings apply to all channels simultaneously.

- Timebase [9-18](#)
- Variable Timebase Mode [9-19](#)
- Time Width [9-19](#)
- Grid Labels [9-20](#)
- Samples [9-20](#)
- Fixed Sampling Rate Mode [9-21](#)
- Sampling Rate [9-21](#)



### 5.6.3 Trigger

This section describes the controls on the Digitizer tab that are used for adjusting the waveform acquisition trigger settings.

- Trigger Delay [9-24](#)
- Trigger Source [9-24](#)
- Trigger Type [9-24](#)

## 5.6.4 Signal Conditioning

This section describes the controls on the Digitizer tab that can be used to set up run-time signal processing, such as signal averaging and filtering. The vertical arrangement of these options mirrors the sequence of acquisition and signal-processing actions. That is, the sampled waveform data is first averaged and then filtered.

- Averaging 
- Filtering 

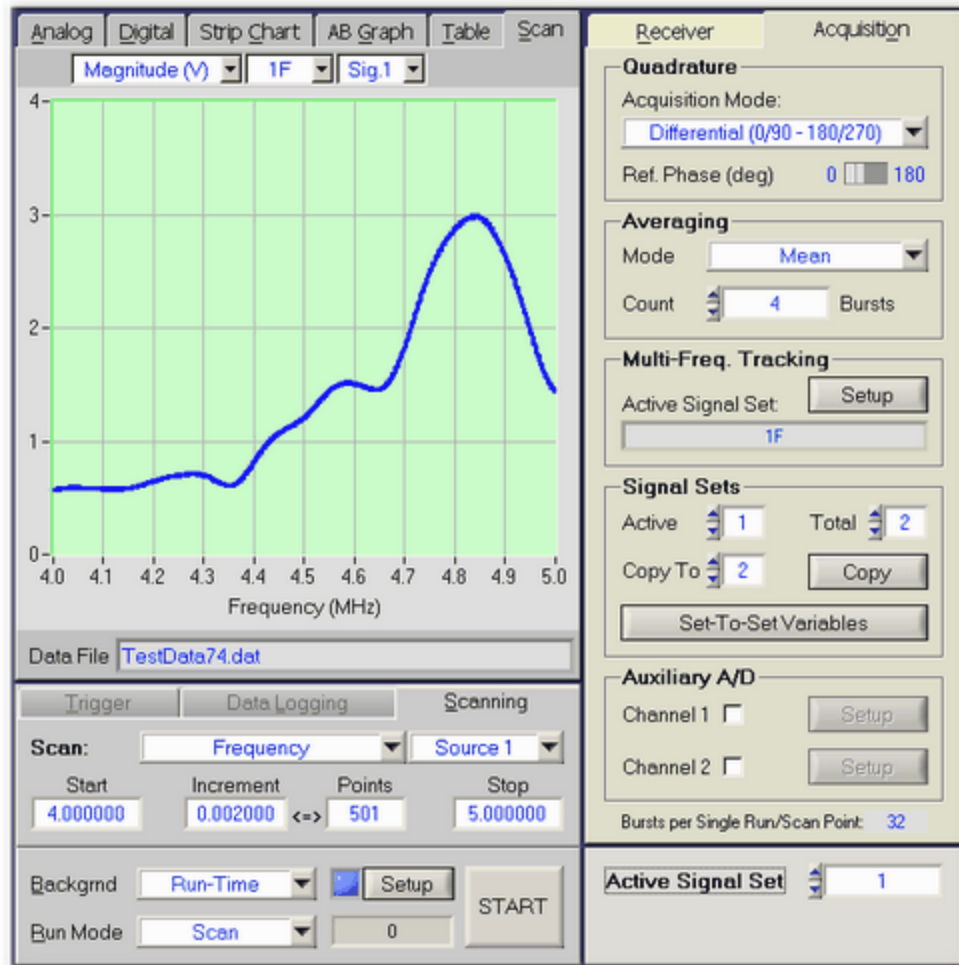
More options are available on the Acquisition Options dialog (see Options  menu), which can be used to set additional sampling and filtering parameters, and to configure Streaming.

# Section 6

---

*Data Acquisition*

## 6 Data Acquisition



This section describes the data acquisition related controls and options that are available with the RAM-5000-M6-Plus User Interface. For data visualization and analysis features, see the section entitled [Data Display](#)<sup>7-2</sup>. For details on specific measurements, see section [Making Measurements](#)<sup>8-2</sup>.

- [Overview](#)<sup>6-2</sup>
- [Acquisition Control Panel](#)<sup>6-3</sup>
- [Acquisition Options](#)<sup>6-23</sup>

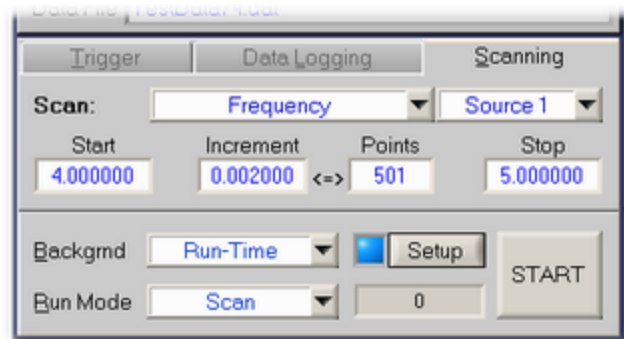
### 6.1 Overview

The RAM-5000-M6-Plus 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](#)<sup>3-5</sup>).

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<sup>6-3</sup>, located directly below the various Data Display<sup>7-2</sup> 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<sup>6-23</sup>, located behind the Receiver Controls Panel. All scanning related data acquisition controls are located on the Scan Panel<sup>6-8</sup>, which can be found among the Data Display panels, as it also contains the scan data view graph.

In the RAM-5000-M6-Plus 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<sup>6-25</sup> setting. If the Quadrature Mode<sup>6-25</sup> 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<sup>6-5</sup> 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



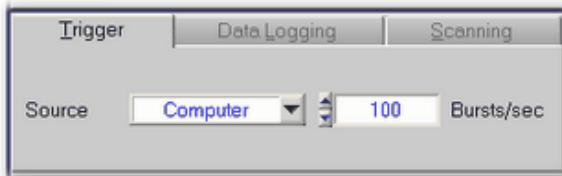
The Acquisition Control Panel when Frequency scanning.

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:

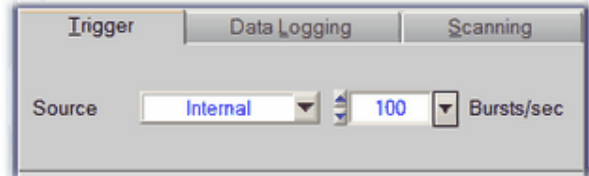
- Trigger<sup>6-4</sup>
- Data Logging<sup>6-6</sup>
- Scanning<sup>6-8</sup>
- Background<sup>6-15</sup>
- Run Modes<sup>6-20</sup>

## 6.2.1 Trigger

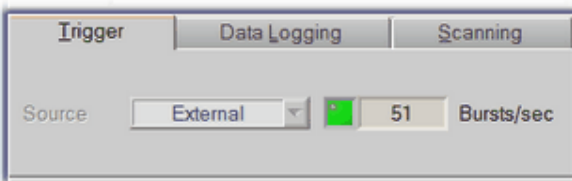
The trigger setup comprises two controls, the Trigger Source [6-4](#) and the Burst Rep-Rate [6-5](#). Depending on the selected Trigger Source, a single burst may be triggered *Manually*, or a Rep-Rate value may be specified for continuous triggering. If the Trigger Source is set to External [6-6](#),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



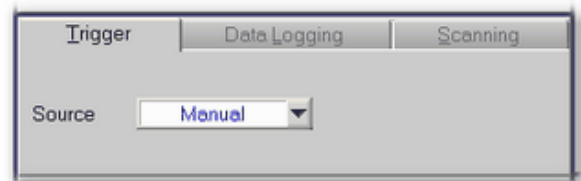
*The Trigger tab when triggering continuously using a software timer.*



*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 [3-16](#) 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-M6-Plus 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>12-8</sup>" of the RAM-5000-M6-Plus 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>3-17</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>6-26</sup> is used, with an averaging count control value of 10, and 2 signal settings<sup>6-30</sup> that have been set up with 2 receiver tracking<sup>5-6</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 Mode<sup>6-25</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-M6-Plus 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-M6-Plus 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-M6-Plus 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-M6-Plus 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.

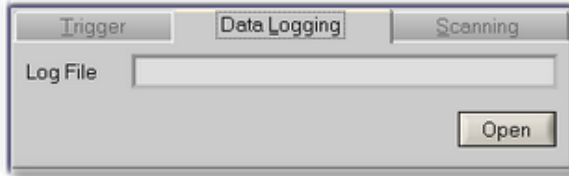
The external trigger rep-rate monitor also includes a green LED, located immediately next to the rate readout. The LED provides an additional visual indication of the external trigger rate and status. Thus, the color of the LED is reset to *green* with each newly registered external trigger event and 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-M6-Plus User Interface at a certain rep-rate before switching to External where the external rep-rate generator is running at the same rate.

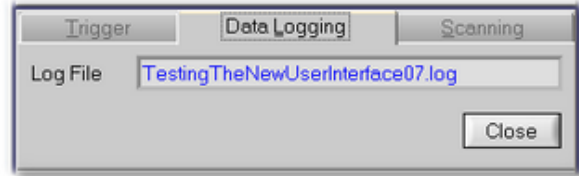
## 6.2.2 Data Logging

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-M6-Plus 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-M6-Plus data log file can contain many columns of data. Yet additional columns could comprise the respective standard deviation data [3-15](#), 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).

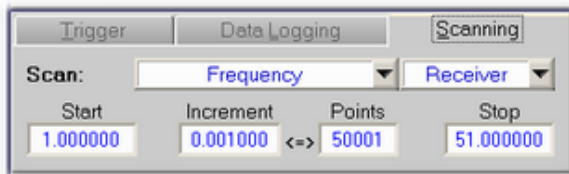
Dependent upon the active acquisition Run Mode [6-20](#), the time stamp data is formatted in one of two ways:

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.

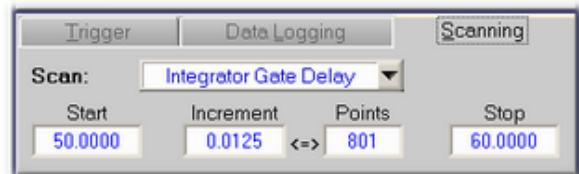
In Run Mode *Continuous*, the time stamp is formatted as *Seconds.Milliseconds* and represents the time relative to when data acquisition was started. Thus, the first logged measurement point will have the relative time stamp data of "0.0". Its absolute time stamp data is stored as part of the column 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 controls related to scanned data acquisition. On this tab, you can set up several different 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 [\[7-18\]](#) documentation.

**Note:** Throughout the RAM-5000-M6-Plus 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.

Scanning is often the basis of a particular measurement. In many cases you can perform more types of measurements [\[3-5\]](#) 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 for your RAM-5000-M6-Plus configuration.

The standard scan types allow for scanning the **Frequency** of either source<sup>[4-3]</sup> or of the receiver<sup>[5-5]</sup>, and for scanning the **Integrator Gate Delay**<sup>[5-9]</sup>. The scan type **Relative Time** allows for performing timed data acquisition, that is, for acquiring any type of data<sup>[7-23]</sup> as a function of time.

In the Advanced Edition of the RAM-5000-M6-Plus 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>[5-8]</sup>, as well as the **Amplitude**<sup>[4-6]</sup> (Synthesizer Output Level), the **Gated Amp. Output Level**<sup>[4-7]</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>[6-30]</sup> and/or multiple receiver tracking frequencies<sup>[6-28]</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>[6-31]</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>[5-6]</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 [5-5](#) 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 [7-20](#) 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 [4-7](#) **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 [4-8](#) and the Bias Level [4-9](#) 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-M6-Plus 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* [\[6-25\]](#), 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-M6-Plus instrument parameter of operation, such as burst frequency or amplitude. Instead, 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-M6-Plus 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-M6-Plus User Interface or a certain voltage change at the TRIGGER IN [\[12-8\]](#) 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-M6-Plus 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<sup>[6-4]</sup> 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<sup>[4-27]</sup> 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<sup>[4-30]</sup> for the Idle Trigger.

**Note:** Independent of the selected Scan Point Trigger, the burst rep-rate<sup>[6-5]</sup> 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-M6-Plus 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<sup>[6-8]</sup>. 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<sup>[3-17]</sup>. 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-M6-Plus 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<sup>[7-20]</sup>. 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<sup>[6-14]</sup>.

**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<sup>[7-25]</sup> dialog, the Graph Properties<sup>[7-26]</sup> dialog, or zoom interactively (see Data Graph<sup>[7-27]</sup>). 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  *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 , a RAM-5000-M6-Plus data

file can contain many columns of data. Yet additional columns could comprise the respective standard deviation data [\[3-15\]](#), as well as certain measurement data [\[8-2\]](#).

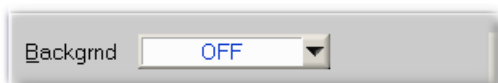
If the Acquisition Mode is set to Trigger Only, then the data file only contains the scan control data which serve as a scan point reference, for example, to post-process waveform data that might have been collected with the Oscilloscope add-on.

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.

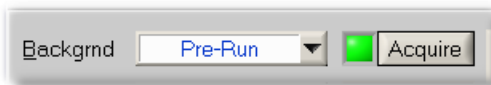
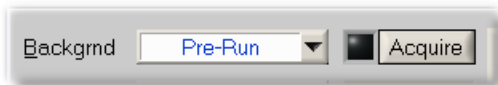
If you choose to disable (see User Interface Preferences [\[3-12\]](#)) the automatically launched file browser dialog at the beginning of each scan, the scan will commence as soon as the START button is pushed. For increased data robustness, the data is still saved to temporary backup file(s) while 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-M6-Plus software installation, even after exiting and restarting the user interface.

## 6.2.4 Background

The control labeled "Backgrnd" is used for enabling background correction. If background correction is enabled, background integrator data is automatically subtracted from signal integrator data at run time. Setting this control to anything other than **OFF**, also determines the acquisition or source 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.

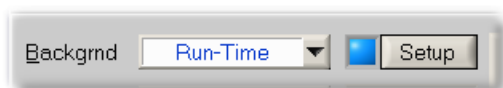


Setting the Background Mode is set to **Pre-Run**, a square LED as well as a button labeled "Acquire" become visible. The color of the LED indicates the integrity status of background in memory. Hovering the mouse pointer over this LED when its color is either *green* or *yellow*, produces a temporary 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-M6-Plus 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-M6-Plus 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.



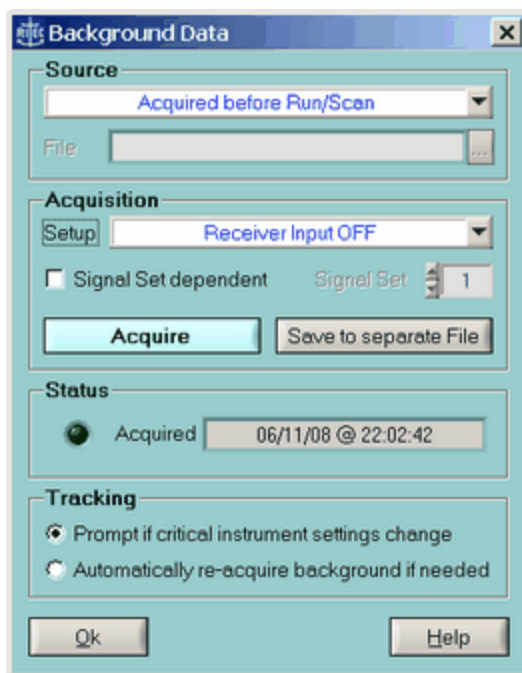
The second additional Background Mode, which is available with the **Advanced Edition** of the RAM-5000-M6-Plus User Interface, is labeled **On-File**. In this mode, background is also subtracted at run-time, however, not acquired but rather loaded from a background data file at some time earlier. With 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

The Background Data dialog box is used to configure each of the available Background Modes. The dialog also allows you to immediately acquire and manage background data, as well as obtain information about it.

**Note:** You can not disable background correction using the Background Data dialog. To turn off run-time background subtraction, you must first close this dialog box and then select the OFF position from the Background Mode control [\[6-15\]](#) located on the Acquisition Control Panel.

The controls inside the **Source** frame determine the acquisition or source mode of the background data. Changing this mode enables or disables various other controls in the Background Data dialog box.



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 should first verify and adjust as needed the *Setup* control setting, located inside the **Acquisition** frame. The available acquisition setup options include **Same Receiver Channel**, **Alternate Receiver Channel**, and **Receiver Input OFF**, **Inactive Gated Amplifier(s)**, and **'Zero' Gated Amp. Control Voltages**. As these labels imply, setting up background acquisition means choosing a particular receiver input or gated amplifier output option. A bit of experimentation with some of these options may be required to find the optimum one for your application.

When using multiple signal settings <sup>6-30</sup>, you also can make the background acquisition 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 five acquisition options.

You can immediately acquire new background for the currently set run mode using the button labeled "Acquire". Once background data has been successfully acquired, the button labeled **Save to separate File** becomes available (**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.

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

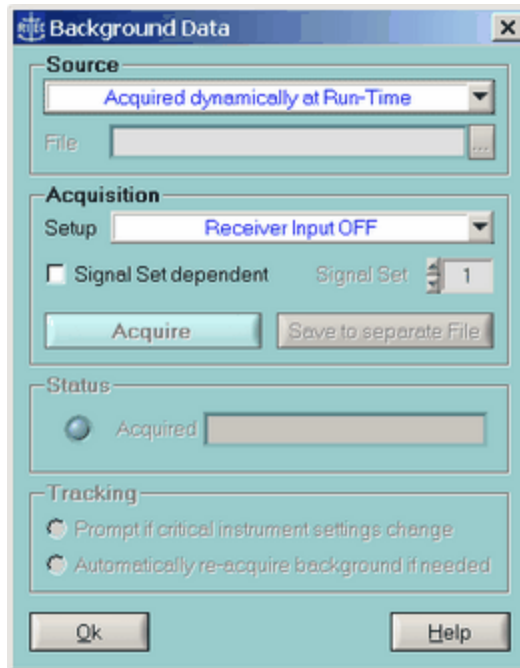
During any type of scan, the background data in memory is automatically saved into a file with the same name as the scan data file (\*.dat), but with the **.bid** extension. This way, you

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.

Before closing the Background Data dialog, you may want to select one of the **Tracking** options. When none of the tracking options is enabled no action (other than updating the status LED) will be taken by the user interface whenever the background validation algorithm detects a problem. Using this setting, you may ignore all warnings, dialogs, or re-acquisition attempts should any occur. Selecting the tracking option **Prompt if critical instrument settings change** causes a dialog to be shown when needed. 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.

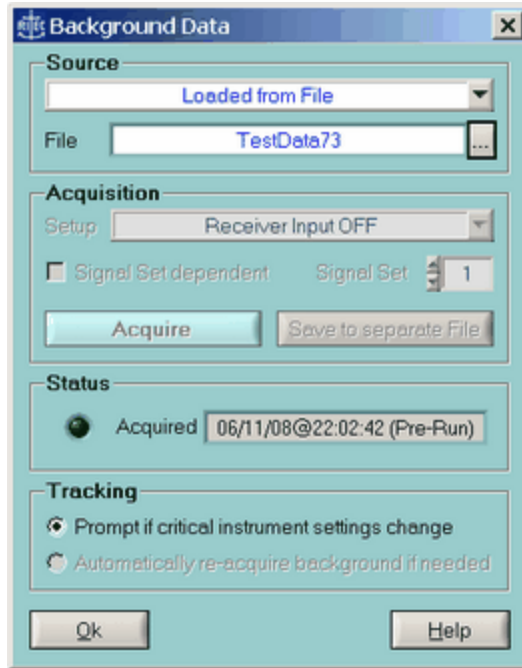
**Advanced Edition:** Selecting the second tracking option, **Automatically re-acquire background if needed**, causes no dialog to be shown when the background validation algorithm detects a problem. Instead, the background data is automatically re-acquired, followed by resuming normal data acquisition without any pause.

**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* controls are available, 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 available. 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 [6-22](#) and the acquisition RUN/START [6-22](#) button. The RAM-5000-M6-Plus 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-M6-Plus User Interface.*

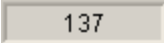
**Continuous** repeatedly executes a full acquisition *cycle* and subsequently updates the display of the chosen data view. Once data acquisition is initiated by clicking the RUN button, it will keep running until you cancel acquisition by clicking the STOP button. Each acquisition *cycle* is automatically *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* [7-18](#) 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 [7-15](#), since it may be used to view data in either run mode.



### 6.2.5.1 Burst Counter

The Burst Counter  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 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

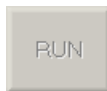
This button is the primary control for beginning and ending data acquisition in accordance with the selected Run Mode [6-20](#).



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



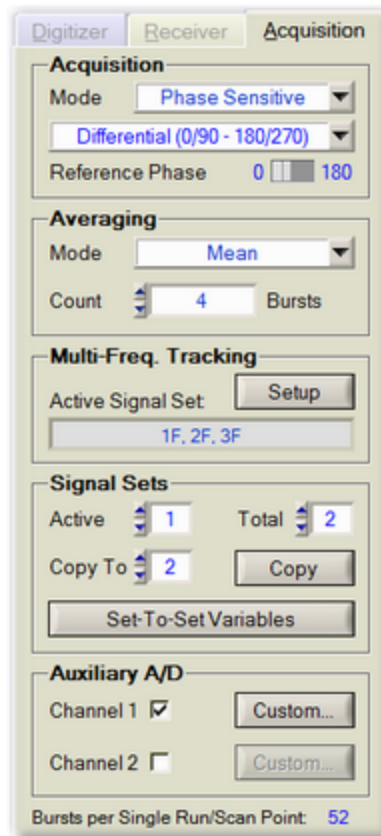
Once any data acquisition is in progress, the button label changes to STOP, and allows you to cancel acquisition.



This button is disabled if using run mode Run Mode *Auto*, as it is managed by the RAM-5000-M6-Plus User Interface.

**Note:** You also can use a keyboard shortcut [3-12](#) to start and stop acquisition. The default shortcut key assignment for this control is **F9**.

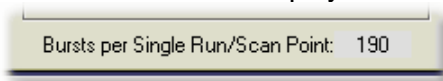
## 6.3 Acquisition Options



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-M6-Plus User Interface executes a Single Run<sup>[6-20]</sup> or processes one Scan Point<sup>[6-8]</sup>. 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/Scan Point" is displayed at the very bottom of the tab.

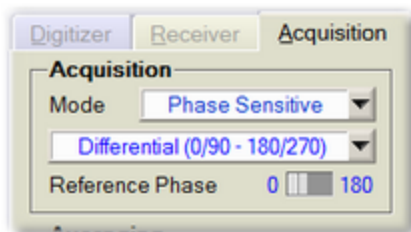


Each group of acquisition options is described in detail below:

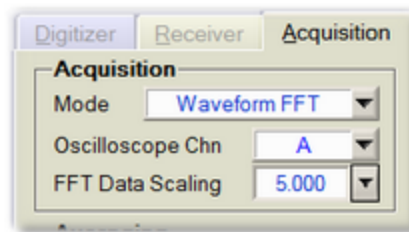
- Acquisition Mode<sup>[6-24]</sup>
- Signal Averaging<sup>[6-26]</sup>

- Multi-Frequency Tracking [6-28](#)
- Multiple Signal Sets [6-30](#)
- Auxiliary A/D Channels [6-33](#)

### 6.3.1 Acquisition Mode



The Acquisition frame after selecting Mode "Phase Sensitive".



The Acquisition frame after selecting Mode "Waveform FFT".

The Acquisition *Mode* determines the type of measurement data you can acquire. The Mode control's drop-down menu allows you to select the primary acquisition mode from 2 different options, namely **Phase Sensitive** or **Waveform FFT**.

When you select **Phase Sensitive**, the primary RAM-5000 measurement data will be obtained using the superheterodyne receiver with quadrature phase sensitive detectors and gated integrators.

**Note:** Please see the Instrument Overview [1-2](#) and the Theory of Operation [11-2](#) help topics for information on how the RAM-5000 superheterodyne receiver with quadrature phase sensitive detectors and the gated integrators operate, and the Signal Detection [5-2](#) help topics for information on how to control related instrument settings.

When operating in the Phase Sensitive mode, you can adjust the Quadrature Mode and the Reference Phase settings to control how the phase-sensitive *data acquisition* is to be performed.

When you select **Waveform FFT**, the primary measurement data will be obtained using an FFT of waveforms acquired with the oscilloscope module.

**Note:** The RAM-5000 oscilloscope module acquires waveform data either using a digitizer that is fully integrated into the RAM-5000 instrument (RAM-5000-PLUS configuration) or a digitizer that is located externally and is supplied separately. An externally located digitizer may even be supplied by the end-user. Please see the Oscilloscope [1-2](#) help topics for information on the supported digitizers, and the Waveform Digitizer [5-15](#) and FFT Detector [5-10](#) help topics for information on how to control related instrument settings.

When operating in the Waveform FFT mode, you can adjust the Oscilloscope Channel and the FFT Data Scaling settings to control which oscilloscope channel is used to supply waveform data to the FFT Detector, and how to scale the obtained FFT data.

### 6.3.1.1 Quadrature Mode

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

In the **Standard** Quadrature Mode, a single burst is transmitted and then analyzed at  $0/90^\circ$  (or  $180/270^\circ$ , depending on the Reference Phase [\[6-25\]](#) setting), to obtain the *In-phase* and the *Quadrature* signal components.

If the Quadrature 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  $0/90^\circ$ , the second is analyzed at  $180/270^\circ$ . The Reference Phase setting determines which pair of phases is applied first. For more information, see Reduction of Measurement Errors [\[11-7\]](#) in the section Theory of Operation [\[11-2\]](#).

**Note:** When using the **Standard** Quadrature 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 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 [\[5-8\]](#) 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 [\[12-3\]](#)), 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 Mode [\[6-25\]](#).

### 6.3.1.3 FFT Oscilloscope Channel

The control, labeled "Oscilloscope Chn", can be used to set the input channel of the oscilloscope that will supply waveform data to the FFT Detector.

This setting defaults to the first available active oscilloscope channel. Any disabled oscilloscope channel will not be usable as input to the FFT Detector.

### 6.3.1.4 FFT Data Scaling

The control, labeled "FFT Data Scaling", can be used to enable and customize scaling of the spectral measurement data to match a certain desired range.

For example, if you select the scaling option **RAM-5000 Phase Detector**, your FFT detected data will exhibit a valid upper limit similar to that of the data obtained using the RAM-5000 phase detector and integrator.

If FFT Data Scaling is disabled, the spectral measurement data obtained from the FFT Detector will be comparable to any displayed Spectrum Analyzer data with a Base Unit setting of "Vrms" at the set detector frequency.

## 6.3.2 Averaging



*Averaging Controls*

The RAM-5000-M6-Plus 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-M6-Plus User Interface, and is available in all data acquisition Run Modes <sup>6-20</sup>. 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

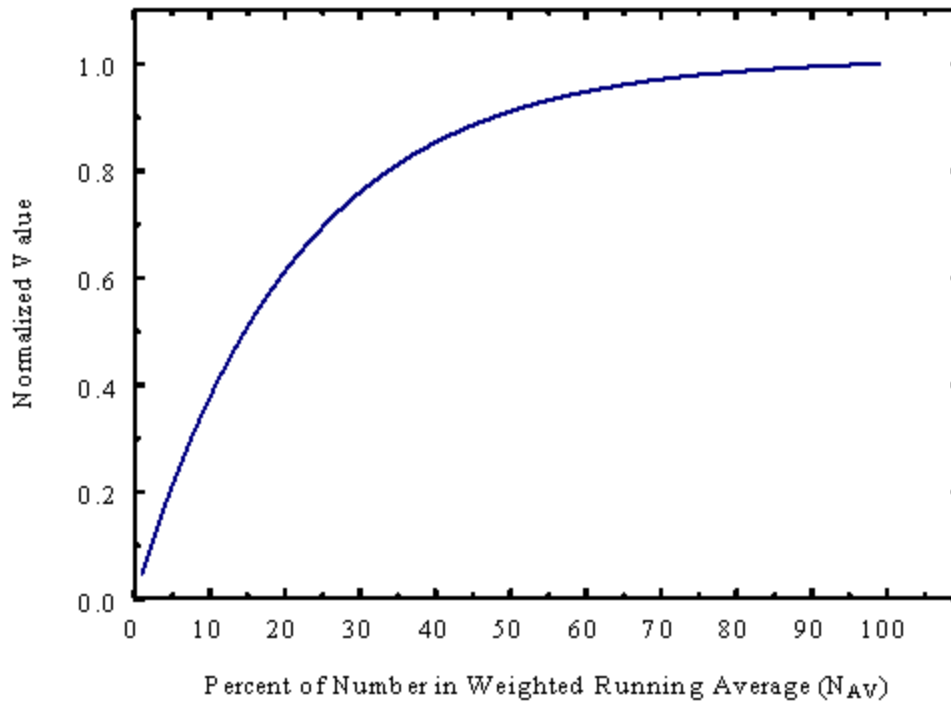
*Advanced Edition only*

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 <sup>[6-20]</sup>. 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,

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

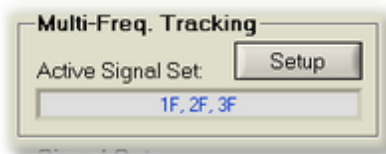


*Response of Weighted Running Average to a Step Function.*

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*

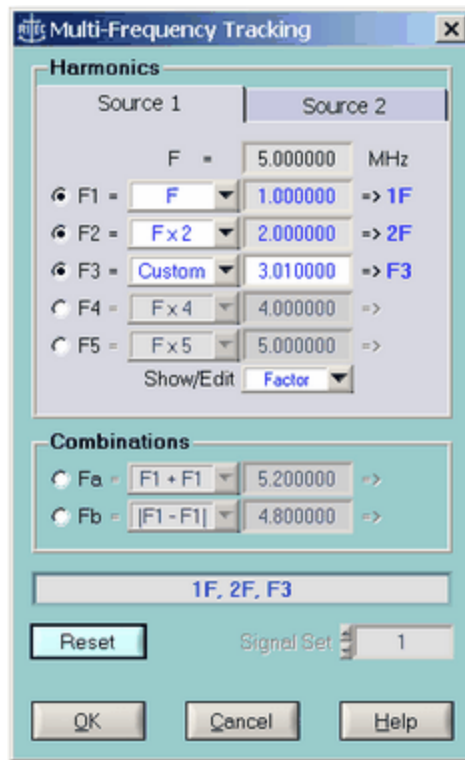
Multi-Frequency Tracking allows you to define multiple receiver tracking frequencies within a single signal set [6-30]. In addition, unlike with standard receiver tracking [5-6], Multi-Frequency Tracking also allows you to define custom tracking frequency.

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  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.

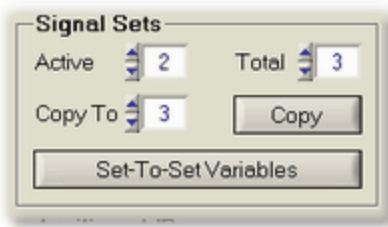
**Note:** Even if certain tracking options on the Multi-Frequency Tracking setup dialog can not be realized due to an instrument's bandwidth limitations, setting up Multi-Frequency Tracking data acquisition configuration can still be very useful for certain experimental scenarios. For example, enabling 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 <sup>[6-28]</sup> 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-M6-Plus 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** <sup>[6-32]</sup>, 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.

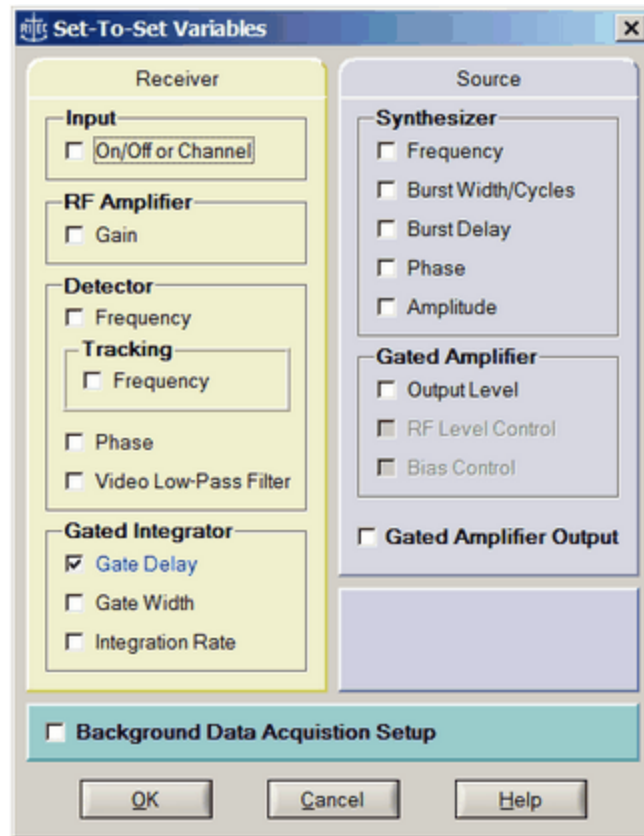
**Total** sets the total number of *defined* signals. The standard limit is 2. With the **Advanced Edition**, this number may be as high as 6. When increasing the number of signals, the user interface automatically initializes each additional signal set based on the currently active one.

**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  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 (represented by a check box on the Set-To-Set Variables setup dialog) 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.

**Notes:** An instrument setting that is dimmed (on the Set-To-Set Variables setup dialog) either can not be independently set for different signal sets or is automatically

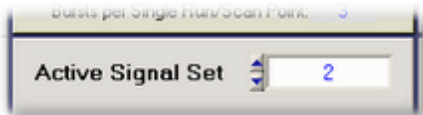
controlled by a related setting. For example, if you check-mark Tracking Frequency, the Detector Frequency setting is inevitably under control of the frequency tracking configuration.

Those instrument settings that are not shown at all on the Set-To-Set Variables setup dialog (such as the Receiver Amplifier High- and Low-Pass filters) can not be rapidly reprogrammed due to certain hardware limitations. Or, are deemed impractical making a set-to-set variable due to the fact that there are too many affected secondary instrument settings.

The check box labeled "Background Data Acquisition Setup" is dimmed whenever background data acquisition and compensation is not used.

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 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 frequency control now produces a context menu which includes the item **Undo Set-To-Set Variable**.

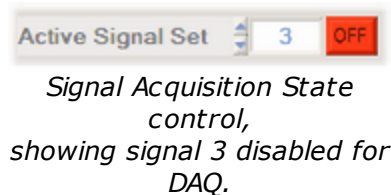
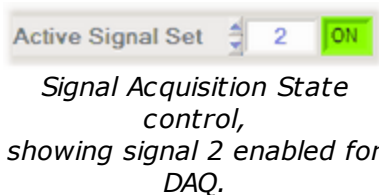
### 6.3.4.2 Active Signal Set



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 <sup>[6-30]</sup>. 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 <sup>[6-31]</sup>, 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 <sup>[7-2]</sup> may also be updated.

**Note:** You also can use various keyboard shortcuts <sup>[3-12]</sup> to set the active signal set. The default shortcut key assignments for this control are **Ctrl+signal set number**, where *signal set number* represents keys **1** through **6**, depending on the number of actually available/defined signal sets. In addition, the default shortcut key assignments for activating the next higher or lower signal set are **F12** and **Shift+F12**, respectively.

### 6.3.4.3 Signal Acquisition State



You can change the signal acquisition state of a Signal Set, using the ON/OFF toggle button next to the **Active Signal Set** control. If the toggle button is in the **ON** position, the respective Signal Set determines the active instrument configuration and data is acquired accordingly, when acquisition is active. This represents the normal state of a Signal Set and is usually the purpose for defining one. However, pressing the toggle button into the **OFF** position, causes the respective Signal Set to be omitted during data acquisition. That means, this Signal Set is still capable of reprogramming the instrument when in the *Idle Trigger*<sup>[4-27]</sup> mode, but is bypassed when acquisition is active. Pressing the toggle button while in the OFF state returns the signal acquisition state back to ON. Changing the acquisition state of a Signal Set is possible when in the *Idle Trigger* mode.

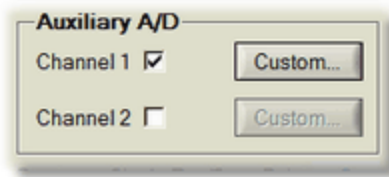
You can toggle the signal acquisition state OFF for multiple Signal Sets. In fact, you can exclude from data acquisition all but one of the defined Signal Sets. This allows you to speed up data acquisition during the process of determining optimum signal setups for your experimental situation, without the need for reducing the number of Signal Sets<sup>[6-30]</sup>.

Another application of this feature would be to use one Signal Set of a multiple signal experimental setup for "parking". For example, suppose you need to drive your transmitting transducer with a very high Gated Amplifier Output Level when making measurements, but do not wish to do so unnecessarily in between measurements. Of course, one way to accomplish this, would be to set the Idle Trigger Rate either very low, or set the Idle Trigger to *Manual*. This, however, would impair the ability to monitor waveform changes on an oscilloscope as a result of possibly needed instrument setup adjustments. Instead, you could use one additional Signal Set (for example, the last in a series of Signal Sets) for automatically setting the Gated Amplifier Output Level very low and adjust the RF Gain accordingly, as soon as data acquisition ends. Thus, you would make this Signal Set be the active one and toggle the signal acquisition state OFF before initiating acquisition.

### 6.3.5 Auxiliary A/D Channels

Two Auxiliary A/D channels, labeled "External Sensor" on the rear panel of the RAM-5000-M6-Plus, 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.



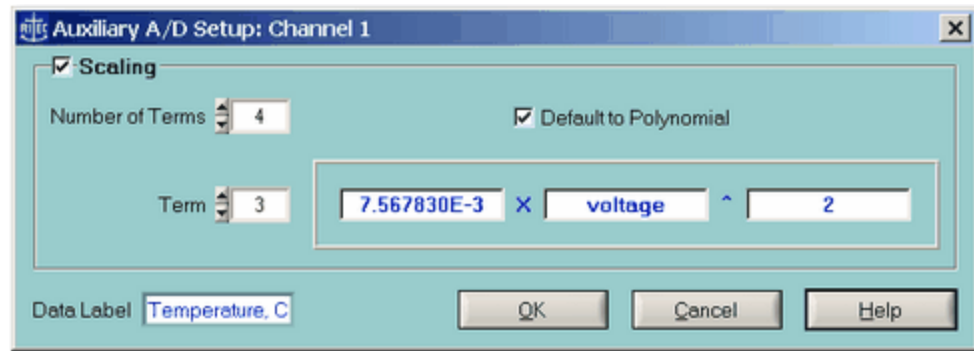
*Auxiliary A/D Channel Controls*

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 [7-23](#) 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-M6-Plus 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.

**Advanced Edition:** To independently set up data scaling on either A/D channel, or to assign a custom data label, press the button, labeled Custom... [6-34](#), 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 [7-2](#) 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-M6-Plus 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.

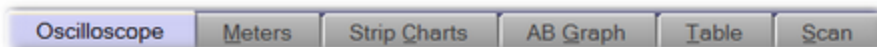
# Section 7

---

*Data Display*

## 7 Data Display

The RAM-5000-M6-Plus User Interface includes a number of different meters, graphs, and a table view, to display acquired data. These data displays are organized onto individual tabs and are located above the Data Acquisition Controls [6-3](#).



*The data display tabs above the acquisition control tabs.*

Below are descriptions of the popup menu options that are shown when right-clicking on the tab's label or the panel associated with the tab. Please note, when you right-click on either meter area the context menu will be different, and are described in the various topics related to each style of meter.

- Release/Confine 'Meters' [7-5](#)
- Help

**Release 'Meters'** frees the Meters tab from the main window of the RAM-5000-M6-Plus user interface and makes the meters available in a separate, freely movable window. To confine the meters back to a tab on the main window, simply close the Meters window by clicking the [x] button on the right of the title bar, or select **Confine 'Meters'** from the popup menu when right-clicking inside the window.

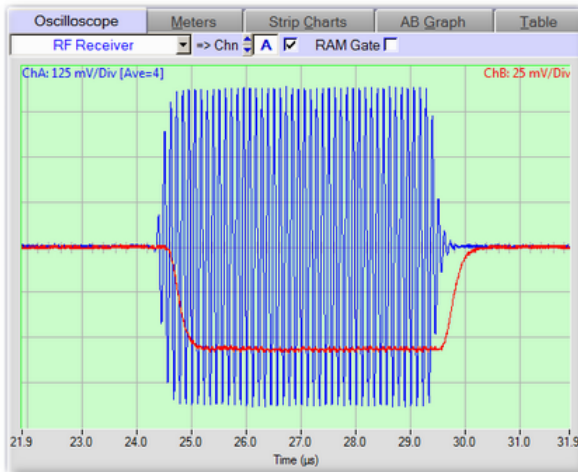
**Help** opens the RAM-5000-M6-Plus Help viewer with help specific to the Meters tab/window.

The following topics describe in detail each data display type and certain controls that are common to all of them:

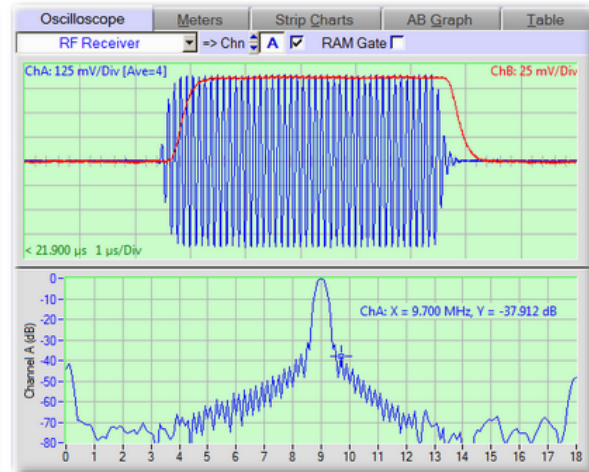
- Oscilloscope [7-3](#)
- Meters [7-5](#)
- Strip Charts [7-8](#)
- A versus B Graph [7-11](#)
- Table View [7-15](#)
- Scan Graph [7-18](#)
- *Common Display Controls* [7-23](#)



## 7.1 Oscilloscope



The Oscilloscope tab with the RF Receiver and Phase Detector 1 signals shown.



The Oscilloscope tab with the Spectrum Analyzer enabled.

The *Oscilloscope* tab can be used for monitoring waveform data acquisition as well as to monitor derived spectral data. The *Oscilloscope* tab is only available when the Oscilloscope is confined to the RAM-5000-M6-Plus User Interface window. Otherwise, you can access the Oscilloscope UI in its own application window.

The following topics describe in detail the various controls and components of the Oscilloscope tab:

- Input Signal Selector [9-13](#)
- Input Channel [9-13](#)
- RAM Gate Channel [9-13](#)
- Waveform Graph [9-8](#)
- Spectrum Analyzer [9-34](#)
  - Spectrum Graph [9-36](#)
  - Analyzer Controls [9-34](#)

Below are descriptions of the popup menu options that are shown when right-clicking on the tab's label or the panel associated with the tab. Please note, when you right-click on either oscilloscope area the context menu will be different, and are described in the various topics related to each oscilloscope graph.

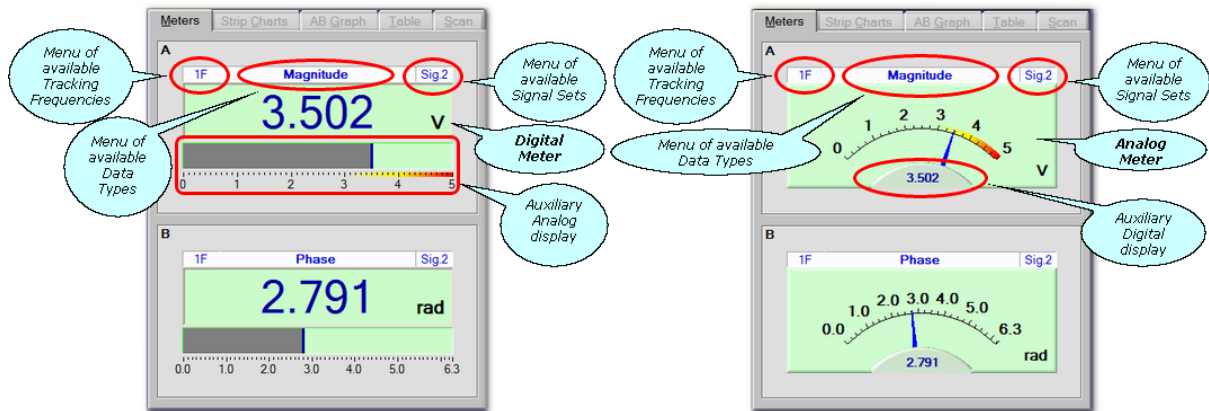
- Release/Confine 'Oscilloscope' [7-5](#)
- Help

**Release 'Oscilloscope'** frees the Oscilloscope tab from the main window of the RAM-5000-M6-Plus user interface and makes the oscilloscope available in a separate, freely moving

application window. To confine the oscilloscope back to a tab on the main window, simply close the Oscilloscope window by clicking the [x] button on the right of the title bar, or select '**Confine to RAM-5000 UI**' from the oscilloscope's Window menu items.

**Help** opens the RAM-5000-M6-Plus Help viewer with help specific to the Oscilloscope tab/window.

## 7.2 Meters



The Meters tab when display style is set to Digital. The Meters tab when display style is set to Analog.

The *Meters* tab can be used for monitoring data acquisition via two meters, one for each data display channel (A and B). Each meter can be configured independently to display any of the available data one measurement point at a time. The primary display style of the meters can also be configured to be either analog or digital (see User Interface Preferences [3-1](#)). In either configuration each meter includes a smaller auxiliary meter, which displays the same data also in the complimentary style for optimum visualization.

The following topics describe in detail the various controls and components of the Meters tab:

- View Tracking Frequency [7-24](#) | Data Type [7-23](#) | Signal Set [7-24](#)
- The Digital Meter [7-6](#) (if primary display style is digital)
  - Auxiliary Analog Display [7-6](#)
- The Analog Meter [7-6](#) (if primary display style is analog)
  - Auxiliary Digital Display [7-7](#)

Below are descriptions of the popup menu options that are shown when right-clicking on the tab's label or the panel associated with the tab. Please note, when you right-click on either meter area the context menu will be different, and are described in the various topics related to each style of meter.


- Release/Confine 'Meters' [7-5](#)
- Help

**Release 'Meters'** frees the Meters tab from the main window of the RAM-5000-M6-Plus user interface and makes the meters available in a separate, freely moving window. To confine the meters back to a tab on the main window, simply close the Meters window by clicking the [x] button on the right of the title bar, or select **Confine 'Meters'** from the popup menu when right-clicking inside the window.


**Help** opens the RAM-5000-M6-Plus Help viewer with help specific to the Meters tab/window.

### 7.2.1 The Digital Meter

The digital meter can be used to view measurement data during acquisition in a precise numerical format with configurable precision.

Located below each digital meter, there is a complementary auxiliary analog display  for showing the same data in a more intuitive format, that is, in terms of a horizontal bar graph.


**Right-clicking** anywhere on the digital meter area produces a context 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-M6-Plus Help viewer with help specific to the digital meter.


### 7.2.2 Auxiliary Analog Display

The horizontal bar graph displays the same data, as selected for the Digital Meter  immediately above it, in a more 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 auxiliary meter produces a context menu with options such as Zoom .

### 7.2.3 The Analog Meter

The analog meter can be used to view measurement data during 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 area produces a context 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 [7-23](#).

**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-M6-Plus Help viewer with help specific to the analog meter.

#### 7.2.4 Auxiliary Digital Display

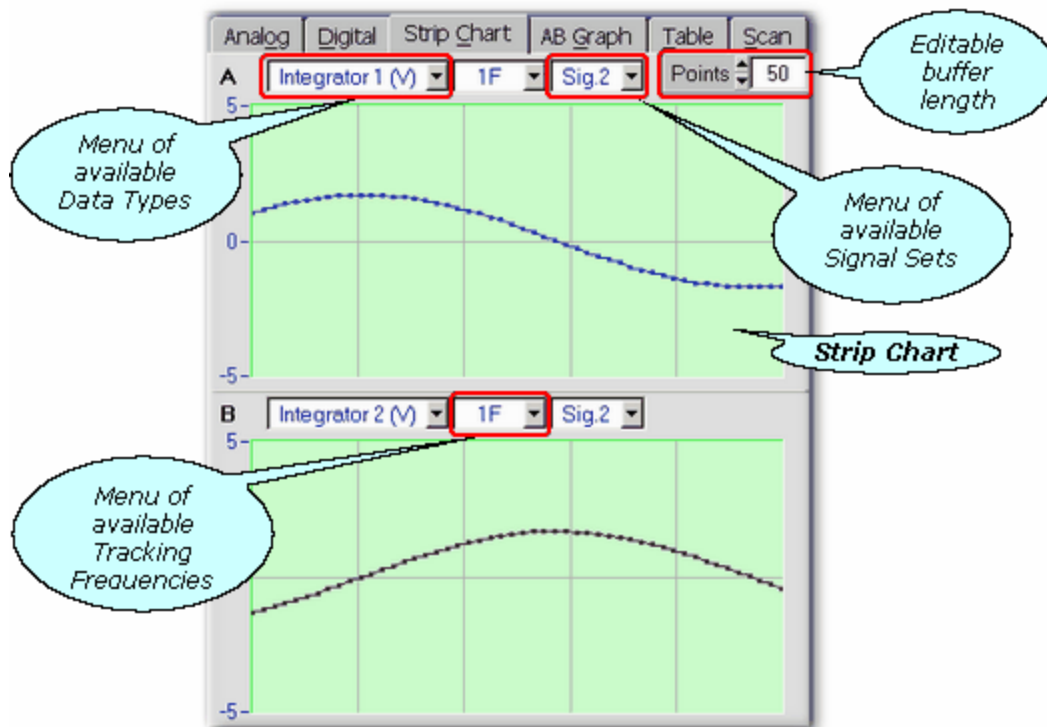
This small digital display is for monitoring the same data, as selected for the Analog Meter [7-6](#) above it, also in a precise numeric format.

The Auxiliary Digital Display is linked to the Digital Meter [7-6](#) (located on the 'Digital' tab) of the same display channel (A or B) in terms of its display properties.

**Right-clicking** the auxiliary readout produces a context menu with options such as display Precision [7-6](#).

## 7.3 Strip Charts

Advanced Edition only



The graphs on the Strip Chart tab.

The *Strip Chart* tab can be used 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 between them up or down using the mouse. To be able to drag the dividing line, you first have to activate it by moving the mouse pointer over the line until its color changes to red and the mouse pointer changes into a different icon.

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

- View Data Type<sup>[7-23]</sup> | Tracking Frequency<sup>[7-24]</sup> | Signal Set<sup>[7-24]</sup>
- View Number of Points<sup>[7-9]</sup>
- The Strip Chart<sup>[7-9]</sup>

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

- Release/Confine 'Strip Charts'<sup>[7-9]</sup>
- Help

**Release 'Strip Charts'** frees the Strip Chart tab from the main window of the RAM-5000-M6-Plus user interface and makes the strip charts available in 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 **Confine 'Strip Charts'** from the popup menu when right-clicking inside the window.

**Help** opens the RAM-5000-M6-Plus 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 [\[7-11\]](#) and the Data Table [\[7-15\]](#), 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 [\[7-9\]](#)). Several options are available to modify the strip chart display properties, including Y axis zoom magnifications with a floating midpoint.

**Right-clicking** when the mouse pointer is located over either axis produces a menu showing all options available for that axis. From the Y axis menu, you may also open a dialog box for editing additional Axis Properties [\[7-25\]](#).


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

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

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

- Y-Axis > Properties... 
- 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.

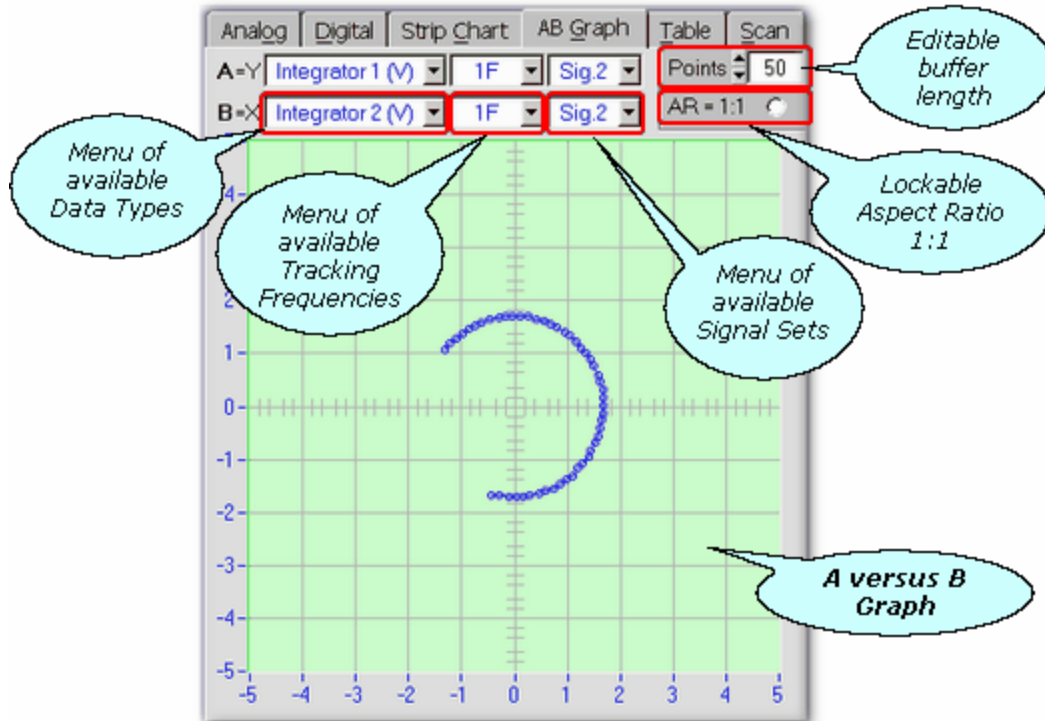
**Y-Axis > Properties...** opens a dialog box for setting additional Axis Properties .

**Help** opens the RAM-5000-M6-Plus 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 can be used 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 [7-23](#) | Tracking Frequency [7-24](#) | Signal Set [7-24](#)
- Plot Number of Points [7-12](#)
- Lock Aspect Ratio 1:1 [7-12](#)
- The AB Graph [7-12](#)

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

- Release/Confine 'AB Graph' [7-11](#)
- Help

**Release 'AB Graph'** frees the AB Graph tab from the main window of the RAM-5000-M6-Plus user interface and makes the A versus B graph available in 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 **Confine 'AB Graph'** from the popup menu when right-clicking inside the window.

**Help** opens the RAM-5000-M6-Plus 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 [\[7-8\]](#) and the Data Table [\[7-15\]](#), 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

The is 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 [\[7-12\]](#)). 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** when the mouse pointer is located over either axis opens a dialog box with editable properties specific to that axis (see Axis Properties [\[7-25\]](#)).

**Right-clicking** when the mouse pointer is located over either axis produces a menu showing all options available for that axis. From this menu, you may also open a dialog box for editing additional Axis Properties [\[7-25\]](#) (same as if **left-double-clicking**).

**Right-clicking** anywhere on the data plot region produces a menu showing options for both axes. In addition, from this menu, you may open another dialog box for editing all Graph Properties [7-26](#) at once, including various data plot properties.

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

- X,Y-Axis > Auto Range [7-13](#)
- X,Y-Axis > Zoom > Interactive [7-13](#)
- X,Y-Axis > Zoom > Full Range [7-13](#)
- X,Y-Axis > Show Grid [7-13](#)
- X,Y-Axis > Log Scaling [7-13](#)
- X,Y-Axis > Properties... [7-14](#)
- Properties... [7-14](#)
- Help

**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 [7-25](#) 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 [7-25](#) 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 [7-25](#)).

**Properties...** opens a dialog box for editing all Graph Properties [7-26](#) at the same time, including various data plot properties.

**Help** opens the RAM-5000-M6-Plus Help viewer with help specific to the AB Graph.

## 7.5 Table View

Advanced Edition only

	Int1	Int2	Mag	Phs
1	0.460	1.617	1.681	2.294
2	0.326	1.637	1.708	1.309
3	0.171	1.657	1.690	1.467
4	0.025	1.677	1.672	1.525
5	-0.129	1.697	1.651	1.643
6	-0.259	1.717	1.676	1.726
7	-0.416	1.737	1.670	1.822
8	-0.559	1.586	1.682	1.910
9	-0.689	1.527	1.675	1.995
10	-0.827	1.447	1.666	2.090
11	-0.948	1.410	1.699	2.163
12	-1.086	1.295	1.690	2.269
13	-1.174	1.205	1.682	2.343
14	-1.300	1.090	1.696	2.444
15	-1.374	0.973	1.684	2.526
16	-1.469	0.855	1.700	2.614

The data matrix view on the Table tab.

The *Table* tab can be used for monitoring measurement data during 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](#) [7-23](#) | [Tracking Frequency](#) [7-24](#) | [Signal Set](#) [7-24](#)
- [View Number of Rows](#) [7-16](#)
- [The Table](#) [7-16](#)

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

- [Release/Confine 'Data Table'](#) [7-16](#)

- Help



**Release 'Data Table'** frees the Table tab from the main window of the RAM-5000-M6-Plus user interface and makes the data table available in 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 **Confine 'Data Table'** from the popup menu when right-clicking inside the window.

**Help** opens the RAM-5000-M6-Plus 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:

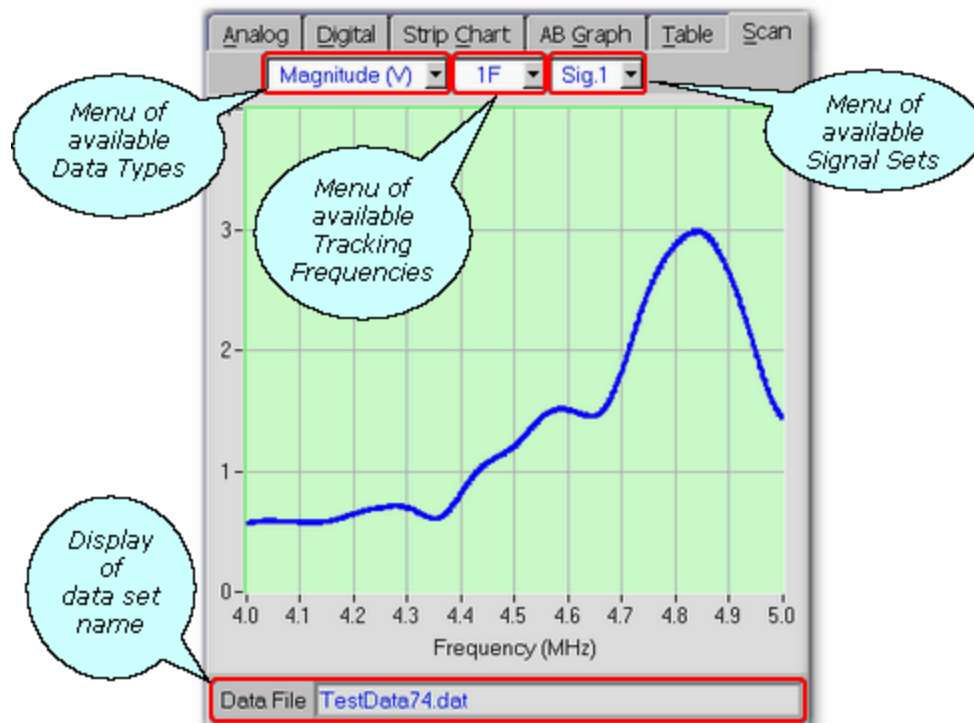
- Copy Selection 
- Precision > 0, 0.0, 0.00, ... 
- Help

**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-M6-Plus Help viewer with help specific to the Data Table.

## 7.6 Scan Graph



The data graph on the Scan tab.

The Scan tab is used 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 [7-23](#) | Tracking Frequency [7-24](#) | Signal Set [7-24](#) | Background
- The XY Graph [7-20](#)
- Data File

Background ...

Data File ...

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

- Release/Confine 'Scan Graph' [7-19](#)
- Copy to New Window [7-19](#)
- Copy to Clipboard [7-20](#)
- Save As... [7-20](#)
- Print... [7-20](#)
- Help



**Release 'Scan Graph'** frees the Scan tab from the main window of the RAM-5000-M6-Plus user interface and makes the scan graph available in a separate window that can be freely moved and sized. *This option is only available in the Advanced Edition of the RAM-5000-M6-Plus User Interface.*

To confine the scan 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 **Confine 'Scan Graph'** from the popup menu when right-clicking inside the window.

**Copy to New Window** copies the content of the Scan tab (if *confined*, or the Scan graph window, if *released*) as presently configured, and including the entire set of data and all settings, into a new window that can be freely moved and sized, and which is then called a Data graph window. *This option is only available in the Advanced Edition of the RAM-5000-M6-Plus User Interface.*

Using the *Copy to New Window* command, you can create a copy of the Scan tab/window and view the contained set of data even after having changed the setup. When changing an instrument operating and/or data acquisition setup, any displayed data acquired with the original setup is usually removed from the graph and from memory. This data is removed, because the new active setup no longer matches the old setup that was used to acquire the previously shown data. Thus, effectively, the Data graph window contains a set of scan data that is decoupled from the instrument state, or "off-line". This allows you to visually compare and analyze up to 10 data sets at a time, even while acquiring new scan data.

You also can use the *Copy to New Window* command to create a duplicate of a Data graph window to view different elements (for example, different data types <sup>7-23</sup>) of a particular data set in several graphs at the same time.

However, with the exception of Graph Cursors, measurements <sup>8-2</sup> can not be enabled or redefined for the data of a Data graph window. That means, if you would like to simultaneously analyze a given set of data using several different measurements or variants of the same measurement, you have to enable or redefine any measurement while the raw data is still linked to the Scan tab/window and then use the *Copy to New Window* command to create a new Data graph window for off-line viewing.

The title of each new Data graph window will read "Data X:", where the X is a number that represents the data set count that is set aside for off-line viewing. Once the data is also saved to a file, the "X:" in the window title is then followed by the name of the data file. And, if you use the *Copy to New Window* command from a Data graph window with the title "Data 5: Water100mm01", for example, the title of the newly created Data graph window will simply read "Copy of Data 5".

The data set contained in a Data graph window does not have to be named (that is, saved to a data file) prior to creating it using the *Copy to New Window* command. You always can save this data to a file at any time using the Data graph window's popup menu item Save Data... <sup>7-20</sup>. **TIP:** When you are working with many open Data graph windows at the same time, it helps to keep them apart with respect to each data set's significance by saving the data and thereby giving each one a name.

men The list of data sets that have been copied into new Scan Graph windows is only maintained within each particular RAM-5000-M6-Plus user interface session. Therefore, the Data Sets menu item is dimmed, if no additional scan data graphs

**Copy to Clipboard** 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.

**Save Data...** opens a file browser to save the current scan data set to a specified folder. Selecting this menu item from the Scan graph window context menu does the same as the File Menu item "Save Data..."<sup>[3-4]</sup>. However, it is useful for saving the data set that is contained in a Data graph window created via Copy to New Window<sup>[7-19]</sup>, if that data was never saved when still shown in the Scan graph window. And, unlike the File Menu item "Save Data...", this menu item is dimmed when the displayed data is already saved and associated with a file name.

**Help** opens the RAM-5000-M6-Plus 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** when the mouse pointer is located over either axis opens a dialog box with editable properties specific to that axis (see Axis Properties<sup>[7-25]</sup>).

**Right-clicking** when the mouse pointer is located over either axis produces a menu showing all options available for that axis. From this menu, you may also open a dialog box for editing additional Axis Properties [7-25] (same as if **left-double-clicking**).

**Right-clicking** anywhere on the data plot region produces a menu showing options for both axes. In addition, from this menu, you may open another dialog box for editing all Graph Properties [7-26] 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 the mouse pointer is located when you right-click.

- X,Y-Axis > Auto Range [7-21]
- X,Y-Axis > Zoom > Interactive [7-21]
- X,Y-Axis > Zoom > Full Range [7-22]
- X,Y-Axis > Show Grid [7-22]
- X,Y-Axis > Log Scaling [7-22]
- X,Y-Axis > Properties... [7-22]
- Hide Legend [7-22]
- Properties... [7-22]
- Hide Cursors/Show Cursors with "..." Readout [7-22]
- Cursors... [7-22]
- Help

**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 [7-25] 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 [\[7-25\]](#) 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 [\[7-25\]](#)).

**Hide Legend** hides the data plots legend that is displayed automatically when there are two or more traces shown on a graph. This menu item is dimmed whenever only a single data plot is shown.

**Properties...** opens a dialog box for editing all Graph Properties [\[7-26\]](#) at the same time, including various data plot properties.

**Hide Cursors/Show Cursors with "..."** **Readout** hides the currently active Graph Cursors [\[7-26\]](#) in the respective graph - OR - shows the last used type of Graph Cursors for the respective graph if none are currently active. The dots inside the double quotes ("...") will be replaced by the name of the most recently used cursor type. For example, if the last used cursors were allowing you to read off differences along both graph axes, the menu item would read *Show Cursors with "X & Y Axis Differences" Readout*.

**Cursors...** opens a dialog box for enabling and configuring various types of Graph Cursors for the respective graph.

**Help** opens the RAM-5000-M6-Plus 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 [7-23](#)
- Tracking Frequency view menu [7-24](#)
- Signal Sets view menu [7-24](#)
- Axis Properties dialog [7-25](#)
- Plot Properties dialog [7-26](#)

### 7.7.1 Data Type

This control is used for selecting the type of data to display in the various meters, graphs, and the table view. The associated drop-down menu lists the different types of available data.

The standard (or, base) data types include the acquired **Integrator 1** and **Integrator 2** A/D voltages, as well as the calculated **Phase** and **Magnitude** (for more information, see Analog Integration [11-6](#)).

By default, the unit of the **Integrator** data and the **Magnitude** data is **V**. The default unit of the **Phase** data is **rad**, however, Phase data can be displayed also in degrees (see Setting User Interface Preferences [3-11](#)).

If there are any measurements [3-5](#) enabled, one additional menu item with a particular label for each measurement parameter is also listed. For example, suppose you have chosen to continuously measure changes in Attenuation and Transit Time relative to their respective initial measurement values at some arbitrary time  $T_0$ . The data type *View Selector* control's drop-down menu would then list two additional items, labeled **Atten. reT0 (dB)** and **Trans. reT0 (ns)**.

If 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 Customization [6-34](#)).

Unlike the meters and graphs, the *View Selector* control of the Data Table [7-15](#) also allows for selecting **All Data** types to be shown at the same time in multiple columns.

The data type *View Selector* control of the Scan Graph [7-18](#) also has one additional menu item, labeled **Integrators**. If you select this, . The menu item Integrators is not available if you are already viewing data from multiple Tracking Frequencies or from multiple Signal Sets in the graph.

## 7.7.2 Tracking Frequency

**Note:** This control is **not visible** if the selected Data View<sup>[7-23]</sup> (e.g., auxiliary A/D or certain measurement parameters) invalidates a tracking frequency view selection, or if Tracking is disabled (Tracking Source<sup>[5-6]</sup> set to NONE) for the selected Signal View<sup>[7-24]</sup>.

This control is used 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<sup>[5-6]</sup> is set up for a particular Signal Set<sup>[6-30]</sup>. 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<sup>[6-28]</sup> 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<sup>[7-15]</sup> 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.

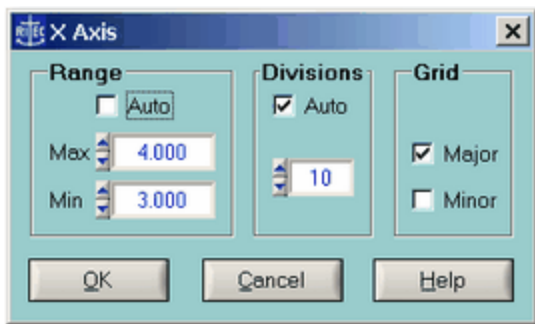
## 7.7.3 Signal Set

**Note:** This control is **not visible** if the selected Data View<sup>[7-23]</sup> (e.g., auxiliary A/D or certain measurement parameters) invalidates a signal view selection, or if only one Signal Set is used.

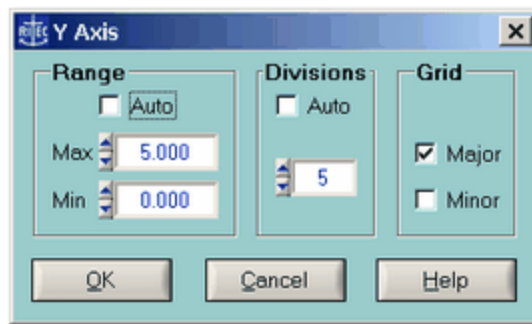
This control is used for selecting the signal set from which to display data in the various gauges (meters), graphs, and the table. If applicable, the associated drop-down menu lists the signal settings that are currently defined.

Unlike with the gauges and graphs, the Signal View selector of the Data Table<sup>[7-15]</sup> 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 used 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** [\[ 7-10 \]](#).

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

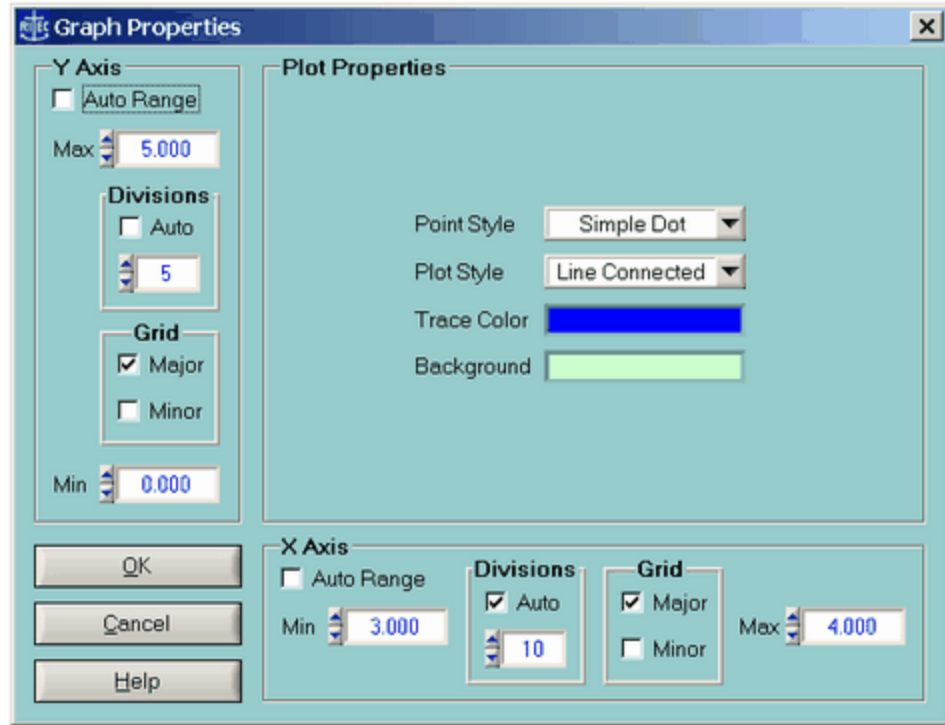
**Auto** enables or disables automatic determination of the optimum numeric increment between the axis labels and the spacing of the major grid. The numeric input is for manually controlling these settings.

### ▪ 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 [\[ 7-25 \]](#) 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>7-22</sup> for the Scan Data Graph).

### 7.7.5 Graph Properties



The Graph Properties dialog.

This dialog box is used 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>7-25</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

---

*Making Measurements*

## 8 Making Measurements

- Overview [\[ 8-2 \]](#)
- Graph Cursors
- Time of Flight and Transit Time [\[ 8-2 \]](#)
- Relative Magnitude, Phase, Propagation Times, and Attenuation [\[ 8-6 \]](#)
- Nonlinear Parameters [\[ 8-12 \]](#)

### 8.1 Overview

The RAM-5000-M6-Plus User Interface includes features that allow you to make many simple and some not-so-simple measurements "right out of the box".

For example, using Graph Cursors you can analyze many types of data sets right on the data graph to obtain differences or ratios.

Using slightly more advanced calculations, you also can 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.

If you are interested in measurements involving acoustic nonlinearities, you can easily set up a variety of nonlinear parameter calculations based on multiple detector tracking frequency data.

**Note:** For additional and more specialized types of measurements, you may wish to use the included API Function Library to write your own custom measurement procedures. If you prefer to not have to spend the extra time and code your own measurement procedure, please contact RITEC for help.

The following topics outline some of the theoretical background for the measurements that are currently implemented:

- Measurement of Transit Time [\[ 8-3 \]](#)
- Measurement of Changes in Transit Time and Attenuation [\[ 8-6 \]](#)
- Measurement of Parameter of Nonlinearity [\[ 8-12 \]](#) *Beta* [\[ 8-12 \]](#)

### 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 dialog box [8-5](#), which can be accessed from the Measurements menu of the Main Menu [3-3](#).

### 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.

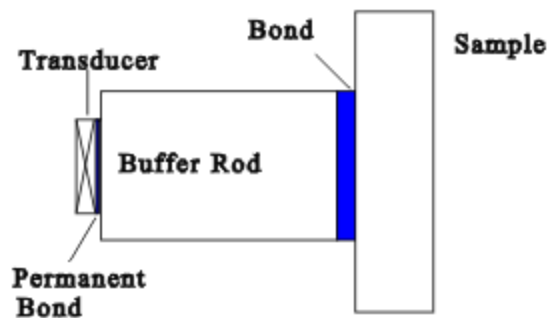


Figure 8-1. Typical acoustic delay line arrangement.

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

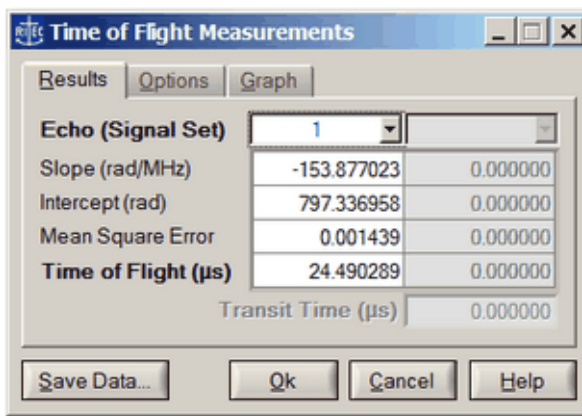
$$\text{Transit Time} = \frac{\left( \frac{\Delta\phi_{r2}}{\Delta F} - \frac{\Delta\phi_{r1}}{\Delta F} \right)}{4\pi(N_2 - N_1)} \quad (8-4)$$

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.

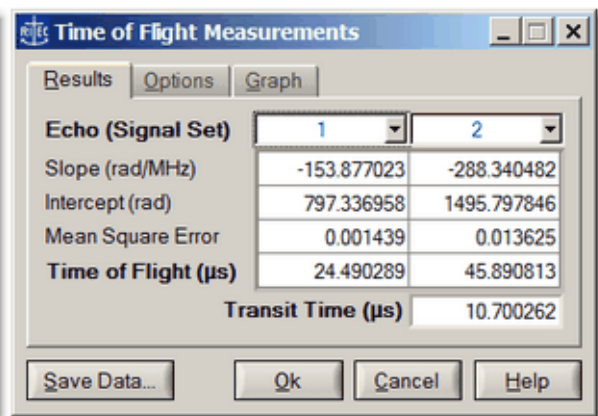
It is recommended that a frequency scan range be as wide as possible for a given transducer because the measurement of slope is more subject to noise and spurious effects than simple voltage measurements. The wide frequency range tends to average out any local variations that may temporarily distort 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 dialog 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-M6-Plus 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.

To copy the transit time data, right-click the displayed value and select *Copy* from the context menu.

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.

## 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 [\[ 8-6 \]](#).

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

### 8.3.1 Measuring Changes in Transit Time and Attenuation

#### ***Measuring Changes in Transit Time ( $T$ ) 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 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:



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

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.

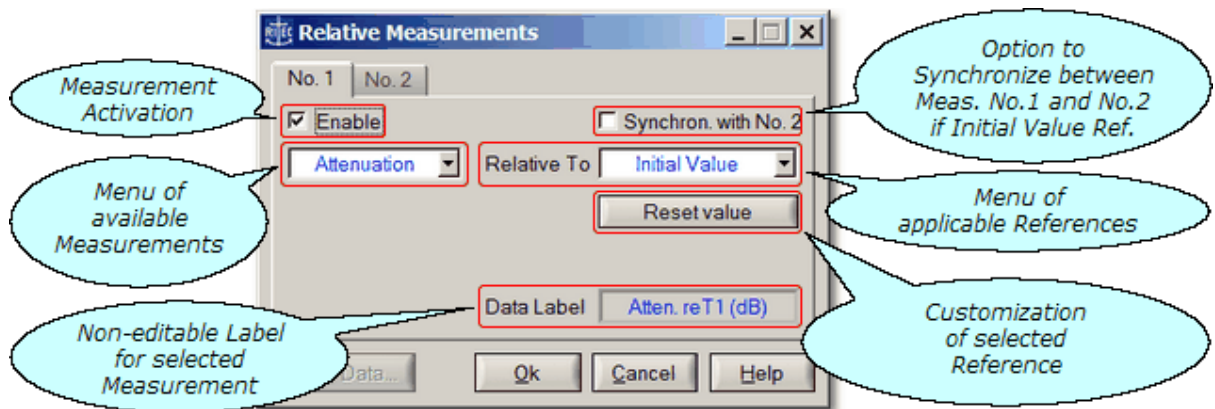
If the user has measured the thickness of the sample ( $h$ ) in cm,  $\Delta\alpha$  may be calculated from:

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

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

**Note:** The procedure implemented in the RAM-5000-M6-Plus 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 dialog is used for setting up measurement data calculations. The available relative measurements include: *Integrator 1*, *Integrator 2*, *Magnitude*, *Phase*, *Delay Time*, *Transit Time*, and *Attenuation*.

The base data Integrator 1 and Integrator 2, as well as Magnitude and Phase, can be measured Relative To their respective *Initial Value*. Integrator 1, Integrator 2, and Phase can be measured also Relative To another *Signal Set*<sup>[6-30]</sup>, provided none of the signal sets also define multiple tracking frequencies<sup>[6-28]</sup> per signal set. However, if you so choose each signal set may define a different single tracking frequency.

The Magnitude data can be measured also Relative To the automatically determined *Maximum Value*, a user-defined *Fixed Value*, or another *Tracking Frequency*<sup>[6-28]</sup> and/or *Signal Set*<sup>[6-30]</sup>, regardless of how complex the tracking frequencies configuration may be. If you have set up both, multiple signal sets and different tracking frequencies per signal set, you will see the option *Tracking Frequency* but not the option *Signal Set* in the drop down menu of the Relative To control. However, when you select the option *Tracking Frequency*, you will be able to "customize" this in terms of a selectable reference tracking frequency and



a selectable reference signal set. That is, Relative To *Tracking Frequency* implicitly includes Relative To *Signal Set*.

If you select the Relative To control setting *Maximum Value*, the RAM-5000-M6-Plus User Interface scales each magnitude data series (i.e., for each tracking frequency and/or signal set) by its maximum value upon loading data from a file or at the end of a data acquisition scan, and expresses the resulting data in dB. At any time, a control button, labeled "Reset Value", can be used to refresh the currently applied reference value and update all calculations and data displays.

This differs from the control setting *Fixed Value*, in which all magnitude data is scaled by one global value that is user editable. When using the *Fixed Value* setting, a control button, labeled "Use Max. Value", can be used to set the fixed value edit field with the current maximum value of all magnitude data.

The measurements *Delay Time*, *Transit Time*, and *Attenuation* can be measured only Relative To their respective *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 data may be reset at any time via the button control, labeled "Reset value". The user interface maintains initial value buffers for all measurements, which allows switching the measurement data without losing coherence between them.

Relative measurements may be performed in all available acquisition run modes<sup>[6-20]</sup> and with certain scan types in run mode *Scan*.

Up to two simultaneous measurements can be enabled, which may optionally be synchronized if both are configured Relative To *Initial Value*.

- in run mode *Scan*, not every type of scan is feasible or makes much sense in with some of the available measurements or a certain reference (i.e., *Relative To* option). For example, the measurements *Delay Time* and *Transit Time*, are not suitable in combination with a

Frequency, Phase, Burst Delay, and Integrator Gate Delay scan. These measurements are therefore unavailable when scanning any of these instrument settings. But please note, if you wish to measure wave propagation time parameters as a function of frequency you can do this using the Time of Flight and Transit Time <sup>8-2</sup> measurements module.

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

Depending on the selected measurement data (*measurement* in picture bubble above) on the left side of the dialog, the right side will be populated with different options. The following table summarizes the options for the various measurement data:

Measurement Data	Relative To	Additional Options	Comment
Integrator 1 Integrator 2 Magnitude Phase Delay Time Transit Time* Attenuation*	Initial Value	<ul style="list-style-type: none"> <li>• Measurement synchronization</li> <li>• Initial value reset at any time</li> <li>• Reference echo selection^</li> </ul>	<p>When in Run Mode <i>Scan</i>, synchronization across measurement channels is always enabled and manual reset of initial reference value(s) are unavailable.</p> <p>* Transit Time and Attenuation measurements available when using 2 or more signal set definitions.</p> <p>^Reference echo selection available when using 3 or more signal set definitions.</p>
Magnitude	Max. Value	<ul style="list-style-type: none"> <li>• Maximum value reset at any time</li> </ul>	Uses separate maximum value for each of the available tracking frequency signals and/or signal sets.
	Fixed Value	<ul style="list-style-type: none"> <li>• Value edit field</li> <li>• Global maximum value determination</li> </ul>	Fixed value reference is used across all of the

Measurement Data	Relative To	Additional Options	Comment
			available tracking frequency signals and/or signal sets.
	Select Tracking	<ul style="list-style-type: none"> <li>Tracking frequency selection</li> </ul>	Select Tracking available when 2 or more tracking frequencies are defined.  Reference value is the magnitude at selected tracking frequency on a point by point basis.
Integrator 1 Integrator 2 Magnitude Phase	Select Signal	<ul style="list-style-type: none"> <li>Signal set selection</li> </ul>	Not available when 2 or more tracking frequencies are defined or when using only 1 signal set definition.

Relative To "Initial Value": Selected data (*measurement* in picture bubble above) for all available tracking frequencies and/or signal sets is offset or scaled by the respective value of the first measurement point in a series of additional measurements. The resulting offset data uses the same base unit as the selected measurement data, except for measurements based on magnitude raw data. For example, if the selected measurement data is either Integrator 1 or Integrator 2, the offset data will also be in Volts. However, if the selected measurement data is Magnitude or Attenuation, the resulting data is the respective measurement data scaled relative to the initial value and expressed in dB.

Clicking the button, labeled "Use max. value", resets the value shown in the edit field to the maximum value of the magnitude data across all available tracking frequencies and/or signal sets. Please note, this is unlike the option Relative To "Max. Value", which automatically uses the maximum magnitude value individually determined for each of the available tracking frequencies and/or signal sets.

Relative To "Fixed Value": Magnitude data (selected *measurement* in picture bubble) for all available tracking frequencies and/or signal sets is scaled by the specified value and then expressed in dB, that is shown in the edit field.

Value = shows currently set value

Clicking the button, labeled "Use max. value", resets the value shown in the edit field to the maximum value of the magnitude data across all available tracking frequencies and/or signal sets. Please note, this is unlike the option Relative To "Max. Value", which automatically uses the maximum magnitude value individually determined for each of the available tracking frequencies and/or signal sets.

## 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 [8-12](#).

You define the Nonlinear Parameter and activate its calculation in the Nonlinear Parameter Measurements Setup [8-14](#) dialog, which can be accessed from the Measurements menu of the Main Menu [3-3](#).

### 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

$$\sigma = C\varepsilon, \quad (8-10)$$

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

$$\sigma = C\varepsilon - D\varepsilon^2. \quad (8-11)$$

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

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

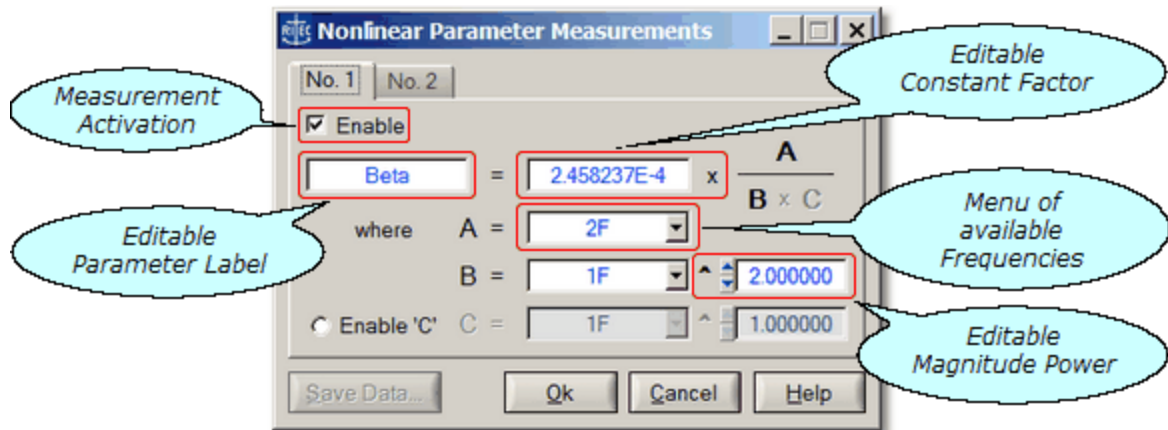
is the fundamental frequency, and  $k = \omega/v$  is the propagation constant. According to Equation 8-15 it follows immediately that the parameter  $\beta$  can be calculated from the acoustically measurable quantities  $A_1$  and  $A_2$  as well as the knowledge of  $v$  and  $a$ , that is

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

The RAM-5000-M6-Plus 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 <sup>8-14</sup>).

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.

- to use this type of measurement in any meaningful way, you have to have set up at least 2 different Tracking Frequencies (see Receiver Tracking [6-5](#) or Multi-Frequency Tracking [6-28](#)), such as a 2F in addition to the standard 1F
- you can set up 2 or more Tracking Frequencies in two ways: A) define 2 or more signal sets, each with a different Tracking Frequency (using Receiver Tracking [6-5](#) with multiple Signal Sets [6-30](#)), B) define multiple Tracking Frequencies within 1 or more signal sets (using Multi-Frequency Tracking [6-28](#)), or C) a combination of both methods
- you can change the Tracking Frequency configuration while the NLP meas dialog is open
- in Table view, when showing "All Data", the defined nonlinear parameter column is shown only, if the Tracking Frequency view control is set to the frequency component A (as opposed to components B or C on the dialog)

Once measurement data is obtained, the **Save** button is enabled (not dimmed), which allows to save all available data to a data file.





# Section 9

---

*Add-on Modules*

## 9 Add-on Modules

### 9.1 Oscilloscope

The User Guide for the Oscilloscope add-on module is divided into the following help sections.

- Overview [9-3](#)
- User Interface [9-4](#)
- General Setup [9-13](#)
- Vertical Controls [9-15](#)
- Horizontal Controls [9-18](#)
- Trigger [9-24](#)
- Acquisition [9-26](#)
- Spectrum Analyzer [9-34](#)
- Storing Data [9-38](#)
- Measurements [9-47](#)

*Version 1.1.11 (October 2023)*

### 9.1.1 Overview







The Oscilloscope software add-on module represents a powerful time-domain data acquisition tool. It offers features that allow the user to rapidly obtain very large amounts of waveform and spectral data without much effort to set up. This type of data acquisition may easily be synchronized with RAM-5000 data acquisition, allowing the user to focus on the experimental work rather than having to spend much time on technical prerequisites.

The Oscilloscope user interface provides control over all instrument operation parameters and features powerful data acquisition and display, as well as signal processing options. For example, acquired waveform data may easily be averaged and/or filtered independently for either analog main input channel at run-time. This data may then be analyzed using the multi-channel Spectrum Analyzer, also at run-time, or via post-processing.

To provide optimum performance, the Oscilloscope add-on module differs from a typical bench-top oscilloscope. It is specifically tailored for the acquisition and analysis of signals at ultrasonic frequencies, and thus “matches” the frequency range of a RAM-5000 system. Because of this and a certain other reasons, it was designed to be used in conjunction with the RAM-5000 for ultrasonic applications, rather than for use as a general-purpose oscilloscope.



## 9.1.2 User Interface






This section provides an overview and describes general features of the software user interface to control the Oscilloscope.

- Overview 
- Main Menu 
- Waveform Graph 
- Display Options 
- Channel Selectors 
- Controlling the Oscilloscope 

### 9.1.2.1 Overview

The Oscilloscope user interface provides control over all instrument operation parameters and features powerful data acquisition and display, as well as signal processing options.

For example, you can display acquired waveform data in a traditional 8-by-10 grid (per division) format or with contemporary graph axes, using either the 8-by-10 or a variable grid when enabling the variable timebase  and/or variable sensitivity  mode.






The layout of the instrument controls was designed to be similar to that of a typical bench-top oscilloscope. On the left, there are the waveform graph and, if enabled, the Spectrum Analyzer  graph. On the right, there are several tabs with controls for setting Horizontal  (tab labeled "X"), Vertical  (tab labeled "Y"), Trigger , and Acquisition  parameters. To make a particular set of controls visible, simply click on their tab.

You can also resize the Oscilloscope user interface window to make it very compact (for example, for using it as a small waveform and spectrum monitoring gauge without showing unneeded controls), or to make it occupy the entire desktop. When you stretch the window vertically, the various tabs automatically separate depending on the available space.

All user interface customization settings are saved and restored when restarting.

### 9.1.2.2 Main Menu

The main menu, located at the top of the Oscilloscope user interface, provides access to a series of named sub menus. Each of these sub menus are described in the following:

- File 
- Measurements 
- Tools 
- Options 
- Window 

- Help  9-7


## File


### *Saving and Loading of Settings*

**Save Settings...** opens a file browser for saving the current digitizer and user interface setup to a settings file with the proprietary file extension ".scoSet". A *scoSet* file is a human-readable text file conforming to the standardized ini-file structure format. Although a *scoSet* file may be viewed, it must never be edited, or else reloading settings from this file is likely to fail.


**Load Settings...** opens a file browser for loading a previously saved digitizer and user interface setup from a settings file. Upon successful reloading of all settings, the digitizer and the user interface are immediately reinitialized to reflect the loaded settings.

### *Saving of Single Sets of Data*

**Save Data...** opens a file browser for saving the currently displayed waveform(s) and, if applicable, associated spectral data to a data file. You can choose from several available file formats .

When saving data in either of the available file formats, a settings file  with the same base filename but always the extension ".scoSet" is automatically created and saved as well.

### *Creating and Opening of a Stream File*

**New Stream...** opens a file browser for creating/starting a special data file for *manual* data streaming. Manual (as opposed to *automated* - see Acquisition Options tab Streaming  for details) data streaming here means, that regardless of the experimental and/or acquisition triggering situation you may have, you retain full control over how and when data is streamed to file (similar to logging data to a file). Once you have successfully started a new stream file, all critical Oscilloscope controls are disabled (dimmed) in the user interface for as long as the same data streaming file remains open (indicated in the Oscilloscope user interface's title bar by the text *Streaming to file...*). However, you may still start and stop digitizer waveform sampling at will, or even change between Single and Normal (continuous) acquisition runs. Before you start a new data streaming file, you must set all Oscilloscope and data acquisition parameters, such as averaging. Then, depending upon your averaging requirements and the pulse trigger repetition rate of your master signal source (for example, your RAM-5000), you will be able to stream multiple waveform and spectral data from consecutive Oscilloscope acquisition runs to file at a rate that you can determine at run-time. You can end a manual data streaming session simply by closing the stream file. You do this by selecting the menu item **Close Stream** from the File Menu, which is available (not dimmed) when data acquisition is stopped. The menu item, **Close Stream**, is actually just the renamed menu item **New Stream...**, which occurs as soon as you successfully start a new streaming file.

When you activate Streaming from the File Menu, you can also save the displayed waveform and spectral data (that is, a *single set of data*) using the menu item Save Data... [9-5], while acquisition is stopped or paused temporarily.

**Open Stream...** opens a file browser for reopening a previously created and closed data-streaming data file for analysis (see Stream File Analysis [9-40] for more details). Similar to when you create a new stream file, many Oscilloscope and user interface controls are disabled (dimmed) for as long as the data streaming file remains open for analysis. That means, the user interface is put into a passive mode (*Deactivated for Stream File Analysis*) in which no acquisition is possible and the Oscilloscope setup, reflecting the original acquisition parameters, cannot be changed.

### Shutting down the Oscilloscope user interface

**Exit**, stops any ongoing digitizer acquisition activities and closes the user interface. The current digitizer and user interface settings are retained by the RAM-5000 user interface and are automatically reused when the Oscilloscope user interface is launched the next time. All digitizer and associated user interface settings are saved inside the master settings file when shutting down the RAM-5000 user interface normally.

## Measurements

The Measurements Menu provides access to simple measurements.

**Cursors** opens the Cursors [9-46] dialog for setting up various types of measurement cursors for each active graph.

**Measure** opens the Measurements [9-47] dialog for enabling scalar-type measurements on any of the active traces.

## Tools

This menu, if present, provides access to various software tools that may have been custom implemented for the Oscilloscope add-on module. The Tools menu also provides access to extra features that may be available with your particular digitizer hardware.

## Options

The Options Menu provides access to additional (less often needed) digitizer configuration settings, advanced acquisition and signal processing options, and various user interface display properties.

**Acquisition** opens the Acquisition Options [9-28] dialog with tabs for setting Sampling, Filtering, and Streaming options.

**Display** opens the Display Options [\[9-8\]](#) dialog for setting various graph and data trace properties.

**Enable Spectrum Analyzer** displays the spectrum graph below the waveform graph as well as the Spectrum Analyzer [\[9-34\]](#) controls, and enables optimized FFT signal processing with real-time spectral data viewing and analyzing. When this option is enabled, the same menu item reads **Disable Spectrum Analyzer**, which allows you to turn off FFT signal processing and hide the Spectrum Analyzer user interface.

## Window

The Window Menu provides options that allow you to create a bitmap image of the present display of the Oscilloscope user interface main window.

**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 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 and opens a Print Options dialog for you to send the image to a printer.

## Help

The Help Menu provides access to various types of information available in the Oscilloscope user interface help viewer.

**Context** opens the help viewer with help specific to the user interface control or item, for example a particular graph, that you last interacted with. Context-related help may also be viewed via the keyboard shortcut **F1**. That means, at any time you can quickly bring up the available help topic(s) specific the control or graph you are currently working with, simply by pressing the **F1** key. Similarly, viewing a specific help topic may also be achieved by right-

clicking the mouse pointer over the user interface item of interest and then selecting the **Help** item from the context menu being displayed.

**Contents** opens the help viewer with the Table of Contents (TOC) visible, the TOC tree collapsed, and showing the introductory help topic.

**Index** opens the help viewer with the Index visible, and showing the introductory help topic.

### 9.1.2.3 Waveform Graph

The waveform graph can display up to two waveform channels simultaneously with separate Y axes or a common Y axis. By default, channel 1 data is plotted against the left Y axis, and channel 2 data is plotted against the right Y axis. When using Channel Equalization [\[9-17\]](#), both channels share a common Y axis on the left of the graph.

The waveform graph can be resized horizontally by resizing the entire Oscilloscope user interface window. It can be resized vertically, either by vertically resizing the entire Oscilloscope user interface window (in this case, waveform and spectrum graphs are always equally high), or by positioning the mouse pointer on the dividing line between waveform and spectrum graphs, then holding down the left mouse button and drag the changed mouse pointer up or down.

X axis zooming and panning may be performed using the Horizontal Zoom [\[9-22\]](#) controls.

Y axis scaling is controlled automatically when setting the Sensitivity [\[9-15\]](#) or the Full Scale [\[9-16\]](#).

### 9.1.2.4 Display Options

The Display Options dialog is for customizing certain graph and data trace properties.

#### *Graph Properties*

**Background** allows you customize the color behind the graph grid and the data traces. Setting this color changes the background of all graphs. To change color, left-click the mouse pointer on the colored rectangle to produce a popup with a color selection dialog.

#### *Trace Properties*

**Point Style** sets the way each individual data sample is marked along a trace. You can choose between *No Marker* and several types of symbols differing in size and shape, such as a *Small* versus a *Large Square*, or a *Diamond* (only one size). Setting the point style property applies to all traces, except the RAM Gate trace [\[9-13\]](#), which is always displayed without marker symbols and only as a thick solid line.

**Plot Style** determines how the data samples are plotted onto a graph, which partly depends on the selected Point Style. If the Point Style is set to *No Marker*, a trace is always plotted in terms of connecting straight line segments, the thickness of which you



can choose as the Plot Style. If the Point Style is set to any other property value, you can set the Plot Style to *Line Connected* (using thin straight line segments) or *Scatter*, in which case you only see actual data samples being plotted.

**Note:** When the Point Style property is set to any other style than *No Marker*, the frequency used for plotting marker symbols is automatically adjusted. If the number of samples plotted exceeds 500 points, the number of markers displayed will vary between 250 and 500. This is to maintain optimum data processing efficiency when acquiring a large number of samples using high trigger repetition rates.

**Color** allows you customize the color of a trace that is associated with a particular channel or the RAM Gate display. Spectrum Analyzer channels use the same color setting as their corresponding waveform channel. That is, setting the trace color for **Chn 1** changes the color of the waveform acquisition channel 1 as well as the spectrum analysis channel 1. To change color, left-click the mouse pointer on the colored rectangle to produce a popup with a color selection dialog.

**Tip:** If you want to view only one trace in a graph with multiple traces enabled (because you need to acquire multiple channels), temporarily set the color value of all other traces either to *Transparent* ("T" in the color selection dialog) or similar to the background color.

**Chn** is for selecting a channel or the RAM Gate (here labeled "IG" for Integrator Gate) display for trace color modification.

All graph and trace properties are updated immediately to see their effect. However, if you close the Display Options dialog by clicking **Cancel**, you'll be able to revert back to the originally set property values, after confirming a warning message dialog.

### 9.1.2.5 Channel Selectors



Throughout the oscilloscope user interface, every Oscilloscope configuration and signal-processing parameter that may be different for each channel is set using a single control (as opposed to having a control for each channel for the same parameter). Therefore, various controls will show a control value that reflect the setting of one particular channel.

To select a channel for viewing and editing any of the channel-dependent settings, you use a Channel control. Several channel selector controls are provided at different places of the user interface, labeled either "Channel" or "Chn". For convenience, one is located where ever there is at least one channel-dependent control nearby. Throughout the user interface, all Channel Selectors are interconnected. That is, when you change the value of one Channel Selector, automatically all others will change to the same value, and all controls and channel-dependent graph displays that are tied to a particular Channel Selector will be updated as well.






The *main* Channel Selector is located next to the Channel Enable control above the primary waveform graph. Additional (that is, *auxiliary*) Channel Selectors can be found on the Vertical Controls [\[ 9-15 \]](#) panel (*Vertical* tab), on the Acquisition Controls [\[ 9-26 \]](#) panel (*Acquisition* tab), on the Acquisition Options [\[ 9-26 \]](#) panel's *Filtering* tab, and on the Display Options [\[ 9-8 \]](#) panel..

You also can use the keyboard shortcut **F5** to change the active *edit* channel, when the Oscilloscope user interface resides in its own movable window and has active focus for keyboard input.

### 9.1.2.6 Controlling the Oscilloscope


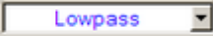
All Oscilloscope settings can be controlled from the Oscilloscope user interface via *menu*, *numeric*, or *knob* controls. A menu control  is used when the control may be set to a limited number of specific options, such as time-per-division settings. A numeric control  is used when the control may be set to a wide range of values, such as trigger delay. When a numeric control involves floating point values, the step size value is handled automatically, as it usually depends on the settings of various other controls. Floating point numeric controls, however, incorporate a mechanism which dynamically increases the step size the longer you continuously press on either arrow button of that control. An editable numeric control may be complemented by a knob control to allow for large changes in the control setting without having to key in each value.

For controlling specific Oscilloscope settings, select the appropriate link below.

- General Setup 
- Vertical 
- Horizontal 
- Trigger 
- Acquisition 


### Menu Controls

This type of control allows you to choose one item from a list to set the labeled value. That is, when you click on such a control with the mouse pointer, a popup menu will list the available settings for that control.

If 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 settings. If the settings involve labels, such as *Lowpass*, *Highpass*, 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 settings 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. “Sample Expand”, 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 using the keyboard.

## 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.

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. "Cutoff Frequency (MHz)", or shows a unit label, e.g. "μs", right next to the edit field, 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 Oscilloscope user interface.

Certain editable numeric controls also have an associated knob control right next to it. These types of controls allow for a series of large changes in the parameter setting without the need to key each new value into the edit field. Each particular knob or slider uses a fixed step size value that has been carefully chosen. Two different types of knobs are implemented, a standard "turn-limited" and a "multi-turn" knob.



A turn-limited knob   covers the entire parameter range within part of a single turn,



which is indicated by numbered tick marks. With a multi-turn type you need to turn the knob several full turns to change the instrument parameter through the entire range, as the valid range may be rather large. This special type of knob is self-evident by the lack of numbered tick marks.



Both types of knobs as well as a slider may be operated via the mouse or the keyboard. To turn a knob using the mouse, simply click the mouse pointer on any part of the center piece and then drags it clock-wise or counter-clock-wise. Using the mouse with a slider is similar to both operating a knob (by dragging the slider pointer) and operating an editable numeric control via the pair of small arrow buttons located on its left side. A slider has *its* arrow buttons at either end of the control. If the knob or slider

has numbered tick marks, you may also quick-select and set a particular control value by clicking on any of the numbers.

Operating a knob or slider using the keyboard is the same as it is with an editable numeric user interface control (see above).

When a knob or slider is operated using either the mouse or the keyboard, the associated numeric edit field is constantly updated with the presently selected and set control value.

### 9.1.3 General Setup

The controls located above the waveform graph are used to activate and custom-label each analog main input channel, and to activate an auxiliary channel to view the RAM-5000 measurement gate.

- Input Signal Selector [9-13](#)
- Input Channels [9-13](#)
- RAM Gate Channel [9-13](#)

The controls located to the right of the waveform graph, that is on the various tabs, are used to set Sensitivity, Timebase, Triggering, Averaging, and other settings. For a description of these controls, see the separate help sections [Horizontal](#) [9-18](#), [Vertical](#) [9-15](#), [Trigger](#) [9-24](#), and [Acquisition](#) [9-26](#).

#### 9.1.3.1 Input Signal Selector

The Input Signal Selector control, located at the far left above the oscilloscope main graph, is used to choose the RF input signal for the chosen oscilloscope channel.

The Input Signal Selector controls this signal selection using the RAM-5000 Signal Monitor Multiplexer [12-4](#) module, in a similar manner with which you can set a certain output signal at the instrument's rear panel. Thus, the list of available input signals is the same as that for any rear panel output channel.

To select a signal as input to the oscilloscope you have to first choose which oscilloscope channel to use and make sure this channel is also enabled.

To disable all input for a particular oscilloscope channel, while keeping that channel enabled, for example to obtain a measure of the instrumentation's noise level, you can select **Monitor Channel OFF**.

#### 9.1.3.2 Input Channels

Use the *Channel Selector* [9-9](#) control to select the analog main input channel that you want to activate. You can activate the channel for data acquisition and signal processing, by clicking (check-marking) the *Channel Enable* control immediately to the right of the Channel Selector. At least one channel will always be active, that is, you cannot disable all channels.

#### 9.1.3.3 RAM Gate Channel

The control, labeled "RAM Gate" (available only when used with the SNAP or the Mark VI configuration), is for viewing the Integrator Gate indicator. If the control is enabled (check-

marked), a bar will be displayed at the top of the waveform graph, indicating the current Integrator Gate Delay and Integrator Gate Width settings in the RAM-5000.

This option effectively adds a third channel to the oscilloscope. Normally one has to dedicate one channel of the oscilloscope hardware to input the analog signal from the Integrator Gate Monitor port at the back of the RAM.

## 9.1.4 Vertical

The controls on the tab labeled "Vertical" are used for controlling vertical waveform acquisition and display settings. These settings apply to the channel selected for editing. To set the edit channel, you use the Channel Selector [9-9](#).

- Sensitivity [9-15](#)
- Variable Gain Mode [9-15](#)
- Full Scale [9-16](#)
- Grid Labels [9-16](#)
- DC Offset [9-17](#)
- Channel Equalization Mode [9-17](#)
- Input Coupling [9-17](#)

### 9.1.4.1 Sensitivity

This control sets the vertical range of the digitizer, in terms of the traditional oscilloscope "volts-per-division" setting, and determines the waveform graph Y axis view range.

The vertical range is the peak-to-peak voltage span that a digitizer can measure at the input connector.

When adjusting the Sensitivity level, and when Channel Equalization [9-17](#) is enabled, the Sensitivity level of all other channels is adjusted. If necessary, the DC Offset [9-17](#) and the Trigger Level [9-25](#) settings may be adjusted.

To set the graph Y axis range to settings other than the ones available with the Sensitivity control, or to have a variable-division grid, switch to the Variable Gain [9-19](#) mode.

**Note:** Sensitivity control values marked by the symbol "\*" represent settings that do not exist as a distinctive vertical range setting of your digitizer. Refer to the Oscilloscope hardware documentation for a list of range settings supported by the device.

**Note:** The Sensitivity control is not available, and is replaced by the Full Scale [9-19](#) control, when using Variable Gain [9-19](#).

### 9.1.4.2 Variable Gain Mode

The checkbox control, labeled "Variable", located below the Sensitivity [9-15](#) / Full Scale [9-19](#) control, is for enabling so-called Variable Gain. If this control is check-marked, the Variable Gain mode is enabled, and the Full Scale control is visible instead of, and at the same location, as the Sensitivity control.

In the Variable Gain mode, you can control the vertical scaling of the waveform graph in fine steps, the size of which is a function of the active vertical range. --- The vertical range that is

active at any given time, is the range setting that is closest to the Full Scale [9-16](#) control value. That means, the vertical range is controlled indirectly. --- In addition, you automatically have a variable waveform graph Y axis grid, and the display of grid labels is enabled.

In the standard gain mode, you directly control the vertical range, in terms of the traditional oscilloscope "volts-per-division" settings, which are typically limited in number. The Y axis grid is fixed and set to 8 divisions. Instead of showing a numbered Y axis (that is, with grid labels), the volts-per-division setting is indicated inside the graph, as it is done on the screen of a traditional oscilloscope. However, displaying a numbered Y axis is still optional using the Grid Labels [9-16](#) control.

### 9.1.4.3 Full Scale

This control sets the vertical range and determines the waveform graph Y axis view range, when working in the Variable Gain [9-19](#) mode.

When adjusting the Full Scale setting, the vertical range that will be active at any given time, is the range setting that is closest to the Full Scale control value. In addition, when Channel Equalization [9-17](#) is enabled, the Full Scale setting of all other channels is adjusted. If necessary, the DC Offset [9-17](#) and the Trigger Level [9-25](#) settings may be adjusted.

To control the digitization voltage range exactly in terms of the traditional oscilloscope "volts-per-division" setting, and to have the fixed 8-division waveform graph Y axis grid, switch to the standard gain control mode, by disabling the Variable Gain [9-19](#).

**Note:** The Full Scale control is not available, and is replaced by the Sensitivity [9-19](#) control, if Variable Gain [9-15](#) is disabled.

### 9.1.4.4 Grid Labels

This control is for enabling the display of labels along the waveform graph Y axis grid, when working in the standard gain mode.

When grid labels are disabled, the current volts-per-division setting is indicated inside the graph.

When displaying grid labels in the standard gain mode, the 8-division voltage grid will remain fixed. To have a variable grid and grid labels, switch to the Variable Gain [9-19](#) mode.

This control is useful when you want to combine the benefits of the traditional 8-division grid with grid labels for easier identification of signal amplitude characteristics.



#### 9.1.4.5 DC Offset

This control sets the vertical offset, or DC offset voltage.

The vertical offset is the voltage the vertical range is centered on. Vertical offset positions a waveform around an arbitrary DC value. Using this offset allows you to examine small changes in the input signal, which can improve the accuracy of your measurement.

When Channel Equalization [9-17](#) is enabled, the DC Offsets settings of all channels are adjusted the same.

#### 9.1.4.6 Channel Equalization Mode

This control is for enabling automatic equalization of channel-based settings.

If Channel Equalization is enabled, the vertical settings range and offset are maintained equal across channels. For example, when the Sensitivity is adjusted, its control setting automatically applies to all channels.

Channel Equalization also applies to Averaging [9-26](#) and all of the Spectrum Analyzer [9-34](#) control options.

When first enabling Channel Equalization, the following actions are performed for all channels:

- Gain Mode is set to the one shown for the *edit* channel.
- Sensitivity/Full Scale is set to the smallest/largest (respectively) of all channels.
- Auto Gain is set to the mode shown for the *edit* channel.
- Grid Labels display is set to the setting shown for the *edit* channel.
- DC Offsets are initially set to zero volts.
- Averaging is configured according to the settings shown for the *edit* channel.
- If the Spectrum Analyzer is active, all control options are configured according to the settings shown for the *edit* channel.

#### 9.1.4.7 Input Coupling

This control is for setting the electrical coupling characteristics for the respective channel input.

The available settings are AC and DC.

DC coupling allows DC and low-frequency components of a signal to pass through without attenuation. In contrast, AC coupling removes DC offsets and attenuates low frequency components of a signal. For example, this allows you zoom in on AC signals with large DC offsets.

## 9.1.5 Horizontal

The controls on the tab labeled "Horiz." are used for controlling horizontal waveform acquisition and display settings. These settings apply to all channels simultaneously.

- Timebase [9-18](#)
- Variable Timebase Mode [9-19](#)
- Time Width [9-19](#)
- Grid Labels [9-20](#)
- Samples [9-20](#)
- Fixed Sampling Rate Mode [9-21](#)
- Sampling Rate [9-21](#)
- Zooming [9-22](#)

### 9.1.5.1 Timebase

This control sets the waveform acquisition length in time, in terms of the traditional oscilloscope "time-per-division" setting, and determines the waveform graph X axis view range.

The Timebase control value, multiplied by a factor of 10 (according to the traditional 10-division grid), represents the acquisition *base* time and graph X axis view *base* range. If Zooming [9-22](#) is enabled (Magnify [9-22](#) settings other than OFF), the timebase value (and X axis view range) may be divided by up to a factor of 100 for the purpose of zooming in time without affecting acquisition parameters.

When adjusting the timebase, either the active sampling rate or the number of samples being acquired will automatically change. You can determine which of the two parameters changes using the Fix Sampling Rate [9-21](#) control setting.

To set the acquisition timebase and graph X axis range *base* to settings other than the ones available with the Timebase control, or to have a variable-division grid, switch to the Variable Timebase [9-19](#) mode.

**Note:** The range of control settings that are available is a mere consequence of the intended use of the Oscilloscope user interface as an add-on module to the RAM-5000 software suite, and is therefore specifically tailored for working with typical ultrasonic operating frequencies. The available range may not reflect the actual sampling capabilities of your digitizer, especially with respect to the lower limit. If your particular application requires Timebase settings lower than the ones currently implemented, please contact customer support for a modified version of the Oscilloscope user interface. Refer to the Oscilloscope hardware documentation for the actual sampling capabilities supported by the device.

**Note:** The Timebase control is not available, and is replaced by the Time Width [9-19](#) control, while using the Variable Timebase [9-19](#) mode.

### 9.1.5.2 Variable Timebase Mode

The checkbox control, labeled "Variable", located below the Timebase [9-18](#) / Time Width [9-19](#) control, is for enabling a variable timebase. If this control is check-marked, the Variable Timebase mode is enabled, and the Time Width control is visible instead of, and at the same location, as the Timebase control.

In the Variable Timebase mode, you can control the waveform acquisition time *base* directly via the Time Width [9-19](#) control in very fine steps, the size of which is a function of the active sampling rate. In addition, you automatically have a variable waveform graph X axis grid, and the display of grid labels is enabled.

In the standard timebase mode, you control the acquisition time *base* indirectly in terms of traditional oscilloscope "time-per-division" settings, which are typically limited in number. The X axis grid is fixed and set to 10 divisions. Instead of showing a numbered X axis (that is, with grid labels), the time-per-division setting is indicated inside the graph, as it is done on the screen of a traditional oscilloscope. However, displaying a numbered X axis is still optional using the Grid Labels [9-20](#) control.

### 9.1.5.3 Time Width

This control is for setting the acquisition timebase when in the Variable Timebase [9-19](#) mode.

The Time Width control sets the acquisition length in time, in terms of the customary "acquisition time" digitization setting, and determines the waveform graph X axis view range.

The Time Width control value represents the graph X axis view range *base*. If Zooming [9-22](#) is enabled (Magnify [9-22](#) settings other than *OFF*), the Time Width value may be divided by up to a factor of 100 for the purpose of zooming in time without affecting acquisition parameters.

When adjusting the Time Width setting, either the active sampling rate or the number of samples being acquired will automatically change. You can determine which of the two parameters changes using the Fix Sampling Rate [9-21](#) control setting.

To control the acquisition time in terms of the traditional oscilloscope "time-per-division" setting, and to have the fixed 10-division waveform graph X axis grid, switch to the standard timebase control mode, by disabling the Variable Timebase [9-19](#).

**Note:** The range of control values that may be set is a mere consequence of the intended use of the Oscilloscope user interface as an add-on module to the RAM-5000 software suite, and is therefore specifically tailored for working with typical ultrasonic operating frequencies. The current range may not reflect the actual sampling capabilities of your digitizer, especially with respect to the lower limit. If your particular application requires Time Width settings lower than the ones currently allowed, please contact customer support for a modified version of the Oscilloscope user interface. Refer to the Oscilloscope hardware documentation for the actual sampling capabilities supported by the device.

**Note:** The Time Width control is not available, and is replaced by the Timebase [9-18](#) control, if the Variable Timebase [9-19](#) mode is disabled.

#### 9.1.5.4 Grid Labels

This control is for enabling the display of labels along the graph X axis grid, when working in the standard timebase mode.

If grid labels are disabled, the current time-per-division setting is indicated inside the graph.

When displaying grid labels in the standard timebase mode, the 10-division time grid will remain fixed. To have a variable grid and grid labels, switch to the Variable Timebase [9-19](#) mode.

This control is useful when you want to combine the benefits of the traditional 10-division grid with grid labels for easier identification of signal time characteristics.

#### 9.1.5.5 Samples

This control is labeled only in terms of the unit "S", and is located to the right of the Timebase [9-18](#) / Time Width [9-19](#) control, as it complements the general timebase setup.

This control sets the number of samples to acquire for each channel, and to use for display in the waveform graph over the specified time range. Therefore, changing the Samples value, automatically changes the sampling rate to match the acquisition Timebase/Time Width setting.

If Zooming [9-22](#) is enabled (Magnify [9-22](#) settings other than OFF), the Samples value may be divided by up to a factor of 100 for the purpose of zooming in time without affecting acquisition parameters.

When setting the Samples control value, the allowable values are subject to the timebase setting and the possible sampling rates. If you desire much finer control over the number of samples base count, you need to do this indirectly, by enabling the Fixed Sampling Rate [9-19](#) mode and then control the acquisition time in the Variable Timebase [9-19](#) mode.

To control the sampling rate and allow the number of samples to acquire to be adjusted automatically, switch to the Fixed Sampling Rate [9-19](#) mode.

**Note:** For certain timebase settings, the range of the Samples control values that may be set will be limited by reaching the limit of available sampling rates. This a mere consequence of the intended use of the Oscilloscope user interface as an add-on module to the RAM-5000 software suite, and is therefore specifically tailored for working with typical ultrasonic operating frequencies. The available range may not reflect the actual sampling capabilities of your digitizer, especially with respect to the lower limit. If your particular application requires sampling rates lower than the

ones currently allowed, please contact customer support for a modified version of the Oscilloscope user interface. Refer to the Oscilloscope hardware documentation for the actual sampling capabilities supported by the device.

**Note:** The Samples control is not available, and is replaced by the Sampling Rate [9-19](#) control, when using the Fixed Sampling Rate [9-19](#) mode.

### 9.1.5.6 Fixed Sampling Rate Mode

The checkbox control, labeled "Fix Rate", located below the Sampling Rate/Number of Samples indicator, is for enabling the Fixed Sampling Rate mode. If this control is check-marked, the Fixed Sampling Rate mode is enabled. Enabling this mode changes the Samples [9-20](#) control into the Sampling Rate [9-21](#) control and changes the Sampling Rate indicator into the Samples indicator.

You can use the Fix Rate control to set whether the active sampling rate or the number of samples to acquire is allowed to change when adjusting the timebase setting.

In the Fixed Sampling Rate mode, the number of samples being acquired vary as a function of the timebase and sampling rate settings. You typically use this mode when you want directly control the sampling rate, and keep it fixed when changing the timebase.

If the Fixed Sampling Rate mode is disabled, the active sampling rate varies as a function of the timebase and number of samples to acquire settings. You would typically want to disable this mode when you need full control over the number of samples count, or when you want to make sure that the number of samples value does not fall below a certain critical value as you might decrease the timebase setting.

### 9.1.5.7 Sampling Rate

This control is labeled only in terms of the unit "MS/s" (Mega Samples per Second), and is located to the right of the Timebase [9-18](#) Time Width [9-19](#) control, as it complements the general timebase setup.

This control sets the sampling rate to use for acquisition and waveform display in the graph. Changing the Sampling Rate value, automatically changes the number of samples being acquired to match the acquisition timebase setting.

If the list of sampling rates initially available is not sufficient for your need, you may easily add more rate control settings by temporarily disabling the Fixed Sampling Rate [9-19](#) mode. You would then change the Samples [9-20](#) control value until the active sampling rate indicator reads the value that you desire. When you now enable the Fixed Sampling Rate mode, the new sampling rate is automatically added to the list. You may repeat this procedure to insert additional control settings.

To control the number of samples to acquire and allow the sampling rate to be adjusted automatically, you need to disable the Fixed Sampling Rate [9-19](#) mode.

**Note:** The range of available sampling rates is a mere consequence of the intended use of the Oscilloscope user interface as an add-on module to the RAM-5000 software suite, and is therefore specifically tailored for working with typical ultrasonic operating frequencies. The available range may not reflect the actual sampling capabilities of your digitizer, especially with respect to the lower limit. If your particular application requires sampling rates lower than the ones currently allowed, please contact customer support for a modified version of the Oscilloscope user interface. Refer to the Oscilloscope hardware documentation for the actual sampling capabilities supported by the device.

**Note:** The Sampling Rate control is not available, and is replaced by the Samples [9-20](#) control, if the Fixed Sampling Rate [9-19](#) mode is disabled.

### 9.1.5.8 Zooming

For horizontal zooming and panning inside the waveform graph, use the controls collectively labeled **Magnify & Position**.

- Magnify [9-22](#)
- Position [9-22](#)

#### Magnify

This control is for enabling horizontal zooming and setting the zoom factor. If zooming is enabled, you can use the Position [9-22](#) controls to pan the X axis view range.

To disable zooming, and to reset the view range, set the control to *OFF*.

Setting this control does not affect waveform acquisition settings and may be done at any time.

#### Position

These controls (a numeric and a turn-limited knob) are for shifting the horizontal view range. The viewable range may either be a magnified timebase, the standard timebase portion of a *sampling expanded* acquisition time, or both.




The Position controls are disabled (dimmed) if the Magnify [9-22](#) control is set to *OFF*. Setting this control to any other value, automatically enables the Position controls.

The control values reflect the positioning reference, which is the left end of a the view range. The Position control may therefore be regarded also as a secondary delay control.

You can quickly jump to either end of the positioning range by clicking on the numeric labels below the knob control.

## 9.1.6 Trigger

The controls on the Trigger tab allow you to set up triggering.

- Trigger Delay 
- Trigger Source 
- Trigger Type 

### 9.1.6.1 Delay

The controls (a numeric, a button, and a multi-turn knob), collectively labeled **Delay**, are for setting the trigger delay.

In general, trigger delay is the amount of time that elapses between when a trigger occurs and when the digitizer actually triggers. This type of delay is also called the *post-trigger* delay, which by definition is always  $\geq 0$ , where "0" marks the time of the trigger event. To allow for a negative trigger delay, the so-called *pre-trigger* delay must be used as well. The Trigger Delay controls implemented here combine the use of pre-triggering and post-triggering transparently into a single Delay parameter.

You can use the button, labeled "Reset", to quickly set the Trigger Delay to zero.

### 9.1.6.2 Source

This control is for setting the source the digitizer monitors for the trigger event.

The available Trigger Source settings are *Internal*, *Channel A*, *Channel B*, and *RAM-5000*. *Channel A* and *Channel B* refer to analog main input channels. *RAM-5000* refers to the external trigger input channel, and *Internal* refers to the RAM-5000 digitizer module's internal trigger generator. When the latter is selected, the digitizer triggers itself, and all other trigger settings are ignored. The digitizer's External trigger input channel is permanently wired to the trigger output line of the RAM-5000 system ("Trigger Out" at the rear panel). Thus, when selecting *RAM-5000* as the trigger source the digitizer is fully synchronized with the various timing settings of the RAM-5000.

### 9.1.6.3 Trigger Type

This control is for setting the type of trigger to use, such as triggering on a simple edge. At present, the following Trigger Types are available:

- Edge Triggering 

#### Edge Triggering

This type of triggering means, a trigger occurs when a signal crosses a trigger threshold that you specify using the Slope and Level controls.

**Slope** controls whether a rising (*POS*) or a falling (*NEG*) edge is supposed to cause the trigger event.



**Level** controls the actual trigger threshold in volts.

If the Trigger Source [9-24](#) is set to one of the analog main input channels, and the Trigger Level setting is out of range with respect to the analog channels vertical range and offset setting, the Trigger Level will be adjusted.

## 9.1.7 Acquisition

The controls on the Acquisition tab allow you to set advanced sampling and run-time signal processing parameters, and to control waveform acquisition. The vertical arrangement of the various control groupings mirrors the sequence of acquisition and signal-processing actions. That is, the sampled waveform data is first averaging-processed and then filtered.

More options are available on the Acquisition Options dialog (see Options [\[9-6\]](#) menu), which can be used to set additional sampling and filtering parameters, and to configure Streaming.

- Averaging [\[9-26\]](#)
- Filtering [\[9-27\]](#)
- Run Controls [\[9-28\]](#)
- More Options [\[9-28\]](#)
- Maximizing Acquisition Speed [\[9-32\]](#)

### 9.1.7.1 Averaging

You can use averaging to reduce the effects of noise. The type of averaging employed is *Continuous Averaging*. When you are Streaming [\[9-39\]](#), the Oscilloscope user interface automatically employs *Summed Averaging* [\[9-27\]](#). Averaging can be configured independently for each acquisition channel, unless Channel Equalization [\[9-17\]](#) is enabled.

The button labeled "Average" enables averaging for the selected channel.

The numeric control next to the *Average* button allows you to specify the maximum averaging count. The meaning of the *count* parameter depends on the type of averaging employed.

***Continuous Averaging*** is based on the following formula:

$$\text{newAverage} = (\text{oldAverage} * [\text{aveCount} - 1] + \text{newData}) / \text{aveCount},$$

where  $1 \leq \text{aveCount} \leq \text{aveCountMax}$ .

This formula is used to continuously compute an updated averaged waveform, *newAverage*, based on an averaging waveform buffer, *oldAverage*, and a newly acquired waveform, *newData*, having unequal weights through the use of the parameter *aveCount*. The corollary parameter *aveCountMax* determines the maximum difference (or ratio) in the two weighting factors. You set this limit via the *averaging count* control value.

The parameter *aveCountMax* thus determines the importance of new data versus old data. That is, the most recently acquired waveform has less weight than all the previously acquired, and the continuous average is less affected by the statistical fluctuations of the most recently acquired waveform. When  $\text{aveCount} = \text{aveCountMax}$ , newly acquired waveforms continue to be added to the averaging waveform buffer, but only have a weight of  $1/\text{aveCountMax}$ .

Continuous averaging is particularly useful for reducing noise on signals that drift slowly in time or amplitude. However, this averaging scheme allows you to make adjustments to a system under test and to see the results immediately, where the response time to a system adjustment is proportional to the *averaging count* control value.

You can reset (`aveCount = 1`) the accumulated average by double-clicking the *Average* button, or by changing an acquisition parameter such as Timebase or Sensitivity. Changing the *averaging count* control value does not reset averaging, it only modifies the used weighting factor. This feature allows you to see more clearly the effect of using different weighting schemes.

To pause averaging, either stop acquisition [manually](#), or change the Acquisition Mode [to Single](#), which will stop acquisition automatically. Averaging will resume when you start acquisition again without changing critical acquisition parameters in the meantime.

The current number of averaged waveforms is indicated inside square brackets, for example, `[Ave=40]`, either on the graph or as part of the Y axis name (when showing Grid Labels [Grid Labels](#)).

**Summed Averaging**, or *mean* averaging, is the addition of  $N$  successive waveforms, divided by  $N$ , where each acquisition has equal weight. The *averaging count* control value specifies the number of acquisitions to be averaged. When the maximum number of acquisitions is reached, the averaging process stops.

This type of averaging is used only while Streaming [Streaming](#). That is, averaged data is saved to file each time the averaging process stops, followed by an automatic reset (`aveCount = 1`) of the *averaging count* to restart averaging.

### 9.1.7.2 Filtering

You can use filtering to remove unwanted parts of a signal, such as high-frequency noise. Filtering employs infinite impulse response (IIR) digital filters, and it can be configured independently for each acquisition channel.




The button labeled "Filter" enables filtering for the selected channel.

All common filter classifications are available, which are:

- Lowpass* --- pass low frequencies and attenuate high frequencies,
- Highpass* --- pass high frequencies and attenuate low frequencies,
- Bandpass* --- pass a certain band of frequencies, and
- Bandstop* --- attenuate a certain band of frequencies.

You can set the desired filter characteristic for the selected channel using the menu control next to the *Filter* button.

To specify the filter frequency for a lowpass or a highpass, you use the numeric control labeled "Cutoff Frequency (MHz)". This label functions as a menu control (indicated by a small red arrow tip pointing down next to label) for selecting "Center Freq. (MHz)" or "Bandwidth (MHz)" to set the respective filter frequency, when performing bandpass or bandstop filtering.

The default Filter Type  used, is a Butterworth of order 2. Other filter types and filter parameters can be configured on the Acquisition Options: Filtering  tab.

### 9.1.7.3 Run Controls

The run controls are for setting the acquisition (trigger) mode and for initiating one or more waveform acquisitions.

**Note:** The run controls are not available, when the Oscilloscope user interface is confined to the RAM-5000 user interface window.

**Mode** controls acquisition timing with respect to the trigger. The setting *Single* is for single-shot acquisitions, while the setting *Normal* is for continuously acquiring.

When the Mode control is set to *Auto*, acquisitions are completed automatically if a trigger has not been received (after a very short wait time). Effectively, this acquisition mode works in a similar way than what the Trigger Source setting *Internal Auto* does. That is, acquisitions are triggered regardless of the actual timing of the trigger signal. However, unlike the *Internal Auto* Trigger Source setting, which ignores all other trigger settings, the various trigger settings are respected (observed).


**RUN/STOP** is used for starting and stopping acquisition. Pressing the RUN state of this button, initiates acquisition by arming the acquisition subsystem and then waits for a trigger. Pressing the STOP state of the button, aborts an acquisition and returns the digitizer to the Idle state. You may want to press STOP and then immediately RUN, for example, if an acquisition seems to have failed, or you are no longer sure about the arm status after an extended period of time without a trigger.

You can also use the keyboard shortcut **F9** to activate acquisition (similar to pressing the RUN state of the RUN/STOP button) and stop acquisition (similar to pressing the STOP state of the RUN/STOP button), when the Oscilloscope user interface resides in its own movable window and has active focus for keyboard input.

### 9.1.7.4 More Options

Use the Acquisition Options dialog for configuring advanced sampling, filtering, and data streaming settings.

- 
- Sampling 
- Filtering 

- Streaming  9-31

## Sampling

The controls on the tab labeled "Sampling" are used to configure advanced data acquisition sampling options.

### ADC Resolution

Use the *ADC Resolution* control to specify the desired number of bits the digitizer will employ for sampling and converting the analog input signal into digital data.

When using 12 bits or more the digitizer's internal memory that is available for capturing data is halved. When using 15-bit resolution only 2 channels can be enabled to capture data, and when using 16-bit resolution only one channel is available.

### Enable Equivalent Time Sampling (ETS)

Enabling Equivalent Time Sampling allows for maximum range of possible sampling rates that your digitizer supports. Disabling this option guarantees that the shortest possible times between consecutive triggers may be achieved at any available sampling rate (real-time sampling only).

Equivalent Time Sampling (ETS) is a way of increasing the effective sampling rate of the digitizer when capturing repetitive signals.

The maximum effective sampling rates that can be achieved with this method are approximately 2.5 GHz.

### **How ETS Works**

ETS works by capturing several cycles of a repetitive waveform, then combining them to produce a composite waveform that has a higher effective sampling rate than the individual captures. The digitizer hardware accurately measures the delay, which is a small fraction of a single sampling interval, between each trigger event and the subsequent sample. Each capture is then shifted slightly in time and overlaid that the trigger points are exactly lined up. The result is a larger set of samples spaced by a small fraction of the original sampling interval.

**Note:** Because of the high sensitivity of ETS mode to small time differences, the trigger must be set up to provide a stable waveform that varies as little as possible from one capture to the next. In addition, when you enable ETS, the Trigger Type will be limited to Edge, and any type of Auto triggering will be unavailable.

**Note:** Only available with compatible digitizers or oscilloscopes, and not available when in RAM-5000 Simulation mode.

## Filtering

The controls on the tab labeled "Filtering" are used to configure advanced settings for analog and digital signal filtering at run-time.

All settings apply to the channel selected for editing (see Channel Selector [9-9](#)).

### Digitizer Bandwidth

Use the *Digitizer Bandwidth* control to specify the maximum input frequency of the channel. The options listed refer to the frequency at which the input circuitry attenuates the input signal by 3 dB. Refer to the Oscilloscope hardware documentation for a list of bandwidths supported by the device.

### Advanced DSP Filter Settings

This group of controls can be used to customize the filter that you select on the Acquisition controls [9-26](#) tab.

### Filter Type

The available filter types include the following digital IIR filter designs which come from the classical analog designs:

- Butterworth
- Chebyshev
- Inverse Chebyshev, also known as Type II Chebyshev
- Elliptic, also known as Caue

These IIR filter designs differ in the sharpness of the transition between the passband and the stopband, and whether they exhibit their various characteristics in the passband or in the stopband. Please refer to the standard literature on IIR filtering and digital signal processing for a detailed discussion of the different filter designs.

### Filter Order

Sets the order of the filter. The order is proportional to the number of filter coefficients used. Increase the filter order to obtain better sharpness of the transition between the passband and the stopband, that is to decrease the width of the transition band. Decrease the filter order to reduce the delay associated with each particular filter design type and characteristic. For example, the time delay for bandpass and bandstop filters is typically twice as large as for lowpass and highpass filters of the same order.

Please note, when you switch to an Inverse Chebyshev, the order should be set higher (at least +3) than you would set for all other filter types, to obtain a comparable passband-to-stopband transition characteristic. For example, if you use a Chebyshev of order 2 and change to an Inverse Chebyshev, you should immediately increase the order to at least 5.

### Passband Ripple

Sets the amplitude, in dB, of the ripple in the passband, when using a Chebyshev or a Caue (elliptic) filter. The ripple (also called peak error) of a filter represents the variation or difference between the actual gain (or attenuation) and the desired gain (or attenuation), and

is typically of equal magnitude across the respective frequency band. In the *passband*, you can usually allow the gain to vary from unity (0 dB) by a small amount.

#### Stopband Attenuation

Sets the minimum attenuation, in dB, of the signal amplitude in the stopband, when using an Inverse Chebyshev or a Cauer (elliptic) filter. An ideal filter would have a gain of zero, or infinite attenuation, in the stopband. In practice, however, the stopband attenuation of the filter cannot be infinite near the transition band. You must therefore specify a value for the minimum acceptable attenuation. The actual attenuation then varies as a function of frequency across the stopband between the specified value and values that approach being infinite, as a result of ripple.

### Streaming

The controls on the tab labeled "Streaming" are used to configure high-speed streaming of acquired waveforms and processed spectra to a data file at run-time.

#### Stream waveform and spectrum data to file when RAM-5000 scanning or logging

When this option is enabled (check-marked), acquisition and streaming of waveform (and possibly spectrum) data is automatically initiated and synchronized with RAM data acquisition. That means, when you start a RAM scan or a RAM data logging session, the Oscilloscope user interface is put under control of the RAM-5000 user interface. The Oscilloscope user interface is partly disabled to prevent subsequent changes to the waveform acquisition setup. A data streaming file is created and initialized, and the Oscilloscope user interface's title bar shows the added text "Streaming to file...". During the scan, a waveform is then saved to file either following each trigger and waveform acquisition, or after every completed averaging cycle (see below for more details). When the scan is finished or aborted, the data streaming file is closed, and the Oscilloscope user interface is fully enabled again. Possibly modified settings, such as the waveform *averaging count* control value, are also restored to their original values.

When this option is disabled, data streaming can also be performed, with or without the RAM-5000. In this case, you would initiate a streaming session manually from the File Menu <sup>9-5</sup> of the Oscilloscope user interface. You may find this feature useful, if you want to perform waveform-based measurements independently from the data acquisition capabilities available with the RAM-5000 user interface.

Using this option allows you to have a set of waveform and spectrum data in parallel with every acquired set of RAM data, fully automatic and without much effort to set up. For every RAM data file, there will also be a *Streaming* data file having the same base file name. You can then post-process this data to extract additional measurement data.

If waveform averaging is used, the Oscilloscope user interface automatically employs Summed Averaging <sup>9-27</sup> instead of Continuous Averaging <sup>9-26</sup>, and the *averaging count* control value will be the same for all channels.

#### Synchronize waveform with RAM averaging

When this option is enabled (check-marked), waveform averaging is controlled from the RAM-5000 user interface. That means, during initialization of a data streaming session,

the waveform averaging control parameters are temporarily adjusted to match the averaging option selected on the RAM-5000 user interface. If RAM averaging is turned *OFF*, there will be no waveform averaging. If the RAM averaging *Count* control is set to 4, for example, waveform averaging will also use an *averaging count* control value of 4, when the RAM Quadrature Acquisition Mode is set to *Standard*. When the Quadrature Acquisition Mode is set to *Differential*, the waveform *averaging count* control value will always be twice as large as the selected RAM averaging *Count* control value.

**Note:** The actual number of waveforms that will be acquired during one RAM averaging cycle may be less than the set *averaging count* [control](#) [value](#), when the time between triggers (as set by the RAM burst repetition rate) is less than or close to the time required for the acquired waveform data to be processed. When this is the case, a certain number of triggers are missed by the waveform acquisition subsystem. However, the start of each new waveform averaging cycle remains synchronized with the start of each new RAM averaging cycle. If you wish to allow for each waveform averaging cycles to be fully completed before starting a new one, lower the burst repetition rate. One way to determine the maximum burst repetition rate for a given waveform acquisition and processing setup is to monitor the final waveform averaging counts while RAM data logging is active which allows you to adjust the trigger rate during a streaming session.

When the *Synchronize waveform with RAM averaging* option is disabled, waveform Averaging can be controlled from the Oscilloscope user interface, while otherwise still under control by the RAM-5000 user interface during a data streaming session. This feature allows you, for example, to have a non-averaged waveform saved after every trigger while saving RAM data that is averaged, or use longer waveform averaging than RAM averaging. The latter case is possible when you acquire RAM data using multiple Signal Sets (that differ only in terms of Detector and/or Gated Integrator settings), or when you use Multi-Frequency Tracking (only the Detector *frequency* setting varies).

This option only applies and is available when the option "Stream waveform and spectrum data to file when RAM-5000 scanning or logging" is enabled. That is, it does not apply when a data streaming session is started manually from the File Menu [of the](#) Oscilloscope user interface.

### 9.1.7.5 Maximizing Speed

The Oscilloscope user interface offers a wide range of waveform acquisition and run-time signal processing options. When using some of these options, please keep in mind the processing capabilities of your computer and possibly other software applications that may all be running at the same time.

When you start noticing a degraded waveform acquisition performance, or other timing issues, consider some or all of the following to maximize acquisition speed:

- Exit as many as possible of the other software applications that may be running, especially the ones that may periodically consume large amounts of CPU time.
- Use Point Style *No Marker* and Plot Style *Thin Line* as Display Options [for](#) viewing traces.



- Reduce in size the Oscilloscope user interface. The larger the graphs, the more time it takes to update their display.
- Disable Filtering [\[9-27\]](#), in particular when acquiring long waveforms.
- Limit waveform acquisition to one channel.
- Reduce the number of Samples [\[9-20\]](#) per waveform, that is, either directly, by reducing the Sampling Rate [\[9-21\]](#), or by reducing the Timebase [\[9-18\]](#) when using a fixed sampling rate.
- Disable Measurements [\[9-47\]](#) and Cursors [\[9-48\]](#) with the "Snap to nearest data point" option enabled.
- Disable the Spectrum Analyzer [\[9-34\]](#), or limit to one channel, and/or do not use the Auto-scaling [\[9-35\]](#) option. You can also enable and use the Spectrum Analyzer when acquisition is stopped, for post-processing of single waveform sets, or for post-processing of multiple waveform sets using Stream File Analysis [\[9-40\]](#).
- Reduce the trigger repetition rate of your signal source, for example the RAM-5000.
- Hide (Minimize) the Oscilloscope user interface.

## 9.1.8 Spectrum Analyzer

The Spectrum Analyzer can process up to two waveform acquisition channels simultaneously to display their scaled amplitude spectra. You can use the Spectrum Analyzer at run-time during waveform acquisition, or when acquisition is stopped for post-processing of single or multiple (Stream File Analysis [9-40](#)) waveforms.

The Spectrum Analyzer allows you to continuously monitor the frequency content of a time domain signal. It can do this using the Fast Fourier Transform (FFT), which is a fast algorithm for calculating the discrete Fourier transform (DFT). The DFT algorithm transforms samples of the data from the time domain into the frequency domain, and thus establishes the relationship between the samples of a signal in the time domain and their representation in the frequency domain.

Below you can find more details on the Spectrum Analyzer.

- Analyzer Controls [9-34](#)
- Spectrum Graph [9-36](#)

### 9.1.8.1 Analyzer Controls

The Spectrum Analyzer is partly controlled using various waveform acquisition controls, and is partly controlled using dedicated controls. The dedicated Spectrum Analyzer controls are located next to the spectrum graph when the Oscilloscope is released from the RAM-5000 user interface into its own application window. When the Oscilloscope is confined to the RAM-5000 user interface, the Spectrum Analyzer controls are located on a tab below the spectrum graph and are always accessible, that is, even if the spectrum graph is not shown. This is so you can then enable the Spectrum Analyzer.

The frequency range and resolution are controlled by way of the Timebase [9-18](#) setting and the active Sampling Rate [9-21](#). For example, when using the Fixed Sampling Rate [9-21](#) mode, doubling the Timebase will double the spectral resolution, as the number of samples acquired will automatically double. On the other hand, when the number of samples are kept constant (Fixed Sampling Rate mode is disabled), doubling the Timebase will cut in half the spectrum frequency range while maintaining the same spectral resolution, as the sampling rate will automatically be cut in half. In general, the frequency range always corresponds to half the active sampling rate value. And, to improve the frequency resolution, increase the acquisition time while keeping the active sampling rate constant.

Various other signal processing and spectral data display options can be controlled for each channel individually. Use the Channel Selector [9-9](#) control to select the Spectrum Analyzer channel you want to enable and configure. When Channel Equalization [9-17](#) is enabled, selecting a channel is meaningful only with regard to the channel *Enable* control.

**Enable** is used to make the selected Spectrum Analyzer channel active. This control is not available (dimmed) for a particular Spectrum Analyzer channel selection, when the corresponding waveform acquisition channel is inactive.

**Window** allows you to apply a scaled window function to the waveform data before performing the FFT. Applying a window function to a signal can be useful for accomplishing several processing and analysis operations. For example, when the waveform signal you want to analyze is poorly defined in time, a window helps to limit the duration of the signal of interest, which can also reduce spectral leakage. Or, using the appropriate window can help to separate a small amplitude signal from a larger amplitude signal with frequencies very close to each other.

The following window functions are available:

- Hanning
- Hamming
- Blackman-Harris
- Exact Blackman
- Blackman
- Flat Top

The *Hanning* window is useful in a variety of applications, including general-purpose, or when the signal content is initially unknown. In particular, *Hanning* may be used when the signal consists of a sine wave or a combination of sine waves. The *Flat Top* window is typically used when accurate single-tone amplitude measurements are of interest. In cases where the signal consists of transients whose duration is shorter than the total acquisition length, it is generally best not to use any window, that is to use the *Windowcontrol* setting *OFF* (*Rectangle*). The same would apply when trying to separate two tones with frequencies very close to each other but with almost equal amplitudes. In general, you might need to experiment with different windows to find the best one for your application.

For a detailed description of the characteristics of these window functions and their use, please see the standard literature on digital signal processing.

**Base Unit** allows you to display the magnitude spectrum in terms of the units *Vrms*, *Vpeak*, or *dB re Vmax*. *Vrms* means volts, root-mean-square, and *Vpeak* means volts, peak-to-peak, whereas *dB re Vmax* means decibels relative to the maximum voltage detected. The latter scales the data logarithmically using the formula  $\text{scaledData} = 20 * \log_{10}(\text{rawData} / \text{maxData})$ , and scales the Y axis range upper limit to 0 dB and the lower limit to the *Range* control value (see below).

**Max (V)** controls the Y axis range upper limit when the Base Unit is set to either *Vrms* or *Vpeak*. The Y axis range lower limit is always fixed and set to 0 volts. This control functions as a meter and displays the maximum voltage detected, when you use Auto-scaling. When detecting the maximum voltage, the DC component is excluded by ignoring the first few points in the spectrum.


**Auto**, when enabled (check-marked), causes the Y axis range upper limit to be automatically scaled when the Base Unit is set to either *Vrms* or *Vpeak*. The maximum voltage detected (disregarding the DC component, and the first few points in the spectrum) is continuously used to update the Y axis range upper limit setting and the *Max (V)* meter display value. Hence, this feature can be used for measuring the voltage at peak frequency.

When you disable this option, the most recently detected maximum voltage (+ 5%) is used to update the Y axis range upper limit setting and the *Max (V)* control value. That is, you can also use the *Auto* control for quickly finding a safe upper range limit value which you then fine-tune when resuming manual range control.

**Range (dB)** controls the Y axis (dynamic) range when Base Unit is set to *dB re Vmax*, or when scaled logarithmically with Base Unit settings *Vrms* or *Vpeak*. In the two latter cases, the range upper limit (reference) can be set using the *Max (V)* control, or is automatically set when Auto-scaling.

**Log Scale**, when enabled (check-marked), causes logarithmic scaling of the Y axis when the Base Unit is set to either *Vrms* or *Vpeak*.

### 9.1.8.2 Spectrum Graph

The spectrum graph can display up to two Spectrum Analyzer channels simultaneously with separate Y axes or a common Y axis. By default, Spectrum Analyzer channel 1 data is plotted against the left Y axis, and channel 2 data is plotted against the right Y axis. When using Channel Equalization , both channels share a common Y axis on the left of the graph.

The spectrum graph can be resized horizontally by resizing the entire Oscilloscope user interface window. It can be resized vertically, either by vertically resizing the entire Oscilloscope user interface window (in this case, waveform and spectrum graphs are always equally high), or by positioning the mouse pointer on the dividing line between waveform and spectrum graphs, then holding down the left mouse button and drag the changed mouse pointer up or down.

X axis zooming and panning may be performed either using the mouse or a set of dedicated controls.

**Zooming:** While mouse pointer is positioned over graph area, hold down Ctrl key, which will cause the mouse pointer to change into a small cross. Next, holding down the left mouse button, drag the cross over the area of the spectrum that you wish to zoom in on. When you release the left mouse button, the X axis range will be rescaled according to the width of the rectangular area you just marked, while the Y axis scaling will be unchanged. To zoom out by 10% of the present frequency range, right-click the mouse pointer over the graph area while holding down the Ctrl key.

**Panning:** While mouse pointer is positioned over graph area, hold down Shift+Ctrl key, which will cause the mouse pointer to change into an open hand. Next, holding down the left mouse button, drag the hand left or right over the spectrum graph to shift the X axis limits interactively. --- To zoom out to the full frequency range and restore the default X axis limits, hold down the Shift key, while the mouse pointer is positioned over the graph area, which will cause the mouse pointer to change into a closed hand. Then right-click the mouse pointer.

If the Oscilloscope is confined to the RAM-5000 user interface, you also have as set of dedicated zoom and pan controls, labeled "Freq. Zoom", "Max (MHz)", and "Min (MHz)", that are part of the Spectrum Analyzer controls tab. When you click on the *Freq. Zoom* control, a drop-down menu gives you a choice of pre-defined zoom levels. To zoom to a custom

frequency range, use the *Max* and/or *Min* control(s). The *Min* control can also be used to pan the currently chosen frequency range.

Y axis scaling and range-setting can be controlled using various Analyzer Controls  9-34.

## 9.1.9 Storing Data

The Oscilloscope user interface allows you to store acquired waveforms and post-processed data, such as spectra, in a number of ways. Of course, you can also store Oscilloscope and user interface setups (see File Menu [9-5](#)).

At almost any time, you can save the currently displayed waveform(s) and associated spectral data [9-5](#) (if the Spectrum Analyzer [9-34](#) is active) to a file in one of several different file formats [9-38](#), for importing into a third-party software application.

In addition, you can use Streaming [9-39](#) to enable a closed-loop process that automatically stores the displayed waveform and spectral data following each trigger, or when certain criteria are met. That is, data is rapidly *streamed* into a special storage file while continuously acquiring new data.

### 9.1.9.1 File Formats

At present, three data file formats are available for storing acquired waveform and spectral data.

Selecting the default (and proprietary) file extension **".scoDat"** (file browser dialog item "Save as type:"), allows you to store the data into a tab-delimited ASCII file with a single header row containing the various column labels. The left-most column always contains the time data followed by the waveform data for each active digitizer channel. The next column would contain the frequency data, which is then followed by the scaled FFT data for each active Spectrum Analyzer channel.

Use the file extension **".mat"** for saving the applicable data into a binary file conforming to the Mathworks MATLAB level 4 file format. The produced *mat* file contains all data necessary to immediately plot or further process the time-dependent signal voltages and, if applicable, the spectra. Also included is the timestamp data for each applicable oscilloscope channel. The timestamp data is represented by a floating point serial number, that is, the number of seconds since 1900 in UTC. It can be converted into a typical time format, as follows:

Suppose a mat file contains streamed waveforms for oscilloscope channel A, which would be stored in the MATLAB array named `TimeStampChn1`.

```
% obtain timestamp data in full seconds only, that is without fractions of one second
TSsecsUTC=floor(TimeStampChn1);
% obtain timestamp data fractions of one second
TSfrac=rem(TimeStampChn1,1);

% convert timestamp data from UTC to local time, here 5 hours later (US East Coast)
TSsecsLocal=TSsecsUTC-(3600*5);
% convert timestamp data local time to MATLAB date number timestamp values relative to the year 1
dnTS1900=TSsecsLocal./86400;
% calculate MATLAB date number timestamp values relative to the present year
dnTS=datenum(1900,1,1,0,0,0)+dnTS1900;

% convert MATLAB data number timestamp values to MATLAB date strings for easier readability here
dsTS=datestr(dnTS);

dsTS =
```

```

01-Feb-2022 20:41:45
01-Feb-2022 20:41:46
01-Feb-2022 20:41:46
01-Feb-2022 20:41:47
01-Feb-2022 20:41:48

% create string array of timestamp data fractions of one second
TSfracStr=num2str(TSfrac', '%.3f');

TSfracStr =
0.318
0.091
0.894
0.707
0.516

% combine MATLAB data string timestamp data with the fractional data in string format
TS=strcat(dsTS,TSfracStr(:,2:end));

TS =
01-Feb-2022 20:41:45.318
01-Feb-2022 20:41:46.091
01-Feb-2022 20:41:46.894
01-Feb-2022 20:41:47.707
01-Feb-2022 20:41:48.516

```

**Note:** The above MATLAB code snippet illustrates only one of many ways to process the RAM-5000 user interface Oscilloscope timestamp data. Depending on your version of MATLAB as well as your intended usage of this data, you may find that there are shorter or better methods of processing the supplied timestamp data.

Choose the file extension **".tdms"** for saving the applicable data into a binary file conforming to the NI TDM Streaming file format. The structure of a *tdms* file is organized primarily into so-called channel groups and channels per group, but also allows for including various data properties and additional custom information. TDM Streaming file data can be loaded into NI DAAdem, NI SignalExpress, or a custom LabVIEW application for further analysis. A *tdms* file usually does not contain time or frequency data channels (that is, arrays). Instead, for efficiency only the start and increment X-data values are stored.

The file extension **".hws"** allows you to save the same data typically stored in a *tdms* file into another binary file format which conforms to the NI Hierarchical Waveform Storage file structure and supports data compression.

Please consult the relevant NI documentation for more details on the NI-TDMS and NI-HWS file formats.

### 9.1.9.2 Streaming

Data streaming involves a special data file into which waveform and, optionally, spectrum data is continuously written and at a rapid pace, possibly each time a newly triggered waveform acquisition is completed. If averaging is used, the data is written at the end of each averaging cycle.

The stream data file conforms to a proprietary file structure with the file extension ".scoBin". A *scoBin* file includes among other things a complete set of digitizer and associated user interface settings, so that no additional settings file (.scoSet) is needed. That means, all information and data necessary to reproduce the digitizer setup used for acquisition as well to correctly display the various data sets contained in the stream file is stored along with the data itself in the same file.

When data streaming is finished, you can reopen the file for analysis using the Stream File Analysis [\[9-40\]](#) dialog, from which you can access the Stream Data Export [\[9-42\]](#) dialog for exporting the data to a new file in a different format. The file formats available [\[9-38\]](#) are the same as for saving a single waveform using the File menu in the Oscilloscope user interface. However, when exporting stream data, multiple data sets can be saved to a single or automatically to multiple new files.

While *streaming* data, the used averaging [\[9-26\]](#) algorithm automatically changes to *Summed* (mean) as opposed to employing *Continuous Averaging*.

You can choose between manual (see File Menu [\[9-5\]](#)) and automated (see Acquisition Options [\[9-31\]](#)) Streaming.

## Stream File Analysis

When you open a RAM-5000 Oscilloscope Data Stream file from the File Menu [\[9-5\]](#), the Stream File Analysis dialog automatically displays.

Using the Stream File Analysis dialog, you can post-process the content of *scoBin* data streaming files that are generated during Streaming [\[9-39\]](#). When post-processing a stream file, you can, for example, play back and view its content using the waveform selection controls [\[9-41\]](#), perform waveform measurements, and perform spectral analyses even if the spectrum analyzer was not used during the original data streaming session. In addition, you can export the content of a stream file [\[9-42\]](#) to another file format. From the Stream File Analysis dialog, you also can open other stream files [\[9-40\]](#) for analysis.

## File Opening

Initially, you open a stream file from the File Menu [\[9-5\]](#), which is automatically followed by displaying the Stream File Analysis dialog. From this dialog, you may then open other stream files to perform additional analysis.

The *File* control shows the name of currently open stream file, without path and file name extension. You can also edit the shown file name to open another stream file. To open the file, use the **Enter** key on your keyboard or select/activate another control. When typing in and/or editing the file name, no path and extension are required. If you don't specify a path, the file is assumed to reside in the same folder as the previous file is located in. However, if you need to open a file located in a different folder, you may specify the path or use the file browser (see below). In addition to showing the name of currently open stream file, the *File*



control is useful, when you have several stream data files whose names differ only a little. For example, file names might be differentiated by a sequential number.

Next to the *File* control, a button, [...], is provided which opens a file browser for opening another stream file.

**Note:** When you open a stream file for analysis, the Oscilloscope user interface automatically looks for a RAM-5000 settings file (.set) with the same base file name as the Oscilloscope stream data file (.scoBin). If such a .set file is found in the same folder which contains the .scoBin file, then the RAM-5000 user interface and instrument hardware is automatically updated and initialized accordingly.

The *Info* box shows information about the stream file. It shows the date and time of the file creation (that is, when the file header was written), the file size, and the data channels contained in the file. The labels "Ch1", "Ch2", and so on, refer to waveform channel data, while the labels "Sp1", "Sp2", and so on, refer to spectral analysis channel data.

## Waveform Selection

To select a particular waveform and, if present, spectral data *stream* (or "block" of the stream file), you can use a pair of controls which reference the stream block's sequence or serial number. A stream block consists of the same amount of data that would be saved to file when you select Save Data...<sup>[9-5]</sup> from the File Menu. The sequence number corresponds to the event number when data was actually written to file during Streaming. The event number may correspond to each trigger event or when a particular averaging cycle was completed.

Use the numeric control, labeled "Data Stream", to search for a stream block by specifying its sequence number in the edit field. Thus, the number in this edit field is always reflective of the currently loaded block of stream data. When this control is the active one (visible edit cursor), you can use the up/down arrow keys on your keyboard to slowly step through the various stream blocks in the file.

Use the slider control to search for a stream block by dragging the blue rectangle along the slide. This allows you to step through the stream file very quickly, which is useful to view the entire content of a stream file like watching a movie with interactive playback speed control. To quick-select a particular sample of the various stream blocks, click on the correspondingly numbered tick mark below the slider. You can also step one stream block at a time, by using the small blue arrow buttons at either end of the slider.

Selecting a stream block means that you can then post-process the loaded set of waveform and, if present, spectral data. For example, you can export the currently displayed data (see File Menu<sup>[9-5]</sup>) to a separate text file for importing it into some other data analysis software application, as opposed to exporting the entire stream file content<sup>[9-4]</sup>. If the stream file contains spectral data, you can deactivate the Spectrum Analyzer<sup>[9-34]</sup> (or just a certain channel) during post-processing to not save unwanted data. On the other hand, if the Spectrum Analyzer was not active during Streaming, you can activate it to view and save the additional spectral data. Or, you may want to enable Horizontal Zooming<sup>[9-22]</sup> during Stream File Analysis to view only certain sections of the waveform data.

The field, labeled "Timestamp", shows the time of day, with millisecond precision, of the timestamp data that is associated with the loaded data stream. If no averaging was used during streaming, Timestamp represents the absolute time when the displayed waveform data was acquired. The date of this timestamp is omitted as it is already referenced in the stream file creation timestamp (see File Info [9-41](#)).

If averaging was used during streaming, Timestamp represents the time when the last waveform in the averaging cycle was acquired. The actual number of waveforms that were acquired during one averaging cycle is shown on the waveform graph for the selected Data Stream. The number of waveforms acquired during one averaging cycle may be less than the set *averaging count* [9-26](#) control [9-26](#) value when using RAM-5000-synchronized averaging (see Acquisition Options: [9-31](#) *Streaming* [9-31](#) for more detail).

## Data Export

To export data streams and save in a different file format, use the Stream File Analysis dialog button, labeled "Export ...". Clicking this button launches the Stream Data Export dialog [9-42](#), which is used to configure, start, monitor, and possibly also cancel the export process.

## Stream Data Export

You can save RAM-5000 Oscilloscope streaming data in a number of different file formats. The file formats available [9-38](#) are the same as for saving a single waveform using the File menu [9-5](#) in the Oscilloscope user interface. However, when exporting data from a *scoBin* [9-40](#) file [9-40](#), multiple data sets can be saved to a single or to a series of new files, using various option settings.

To export from a *scoBin* file data store, you first have to open this file for content analysis, either from the Oscilloscope user interface's File menu [9-6](#) or using the File controls [9-40](#) of the Stream File Analysis dialog [9-40](#). Next, you launch the Stream Data Export dialog by clicking the *Export...* button in the Stream File Analysis dialog box.

Using the Stream Data Export dialog, you can, for example, specify to export all available data streams or only a certain range, using the Export Range [9-44](#) group of controls. You also can set various output file options [9-44](#) that determine the output file format, as well as the maximum file size or file count. Some amount of experimentation with the various export options may be required to determine the optimum settings for your particular need.

In addition to the setting of various data export option, the Stream Data Export dialog is also used to start, monitor, and possibly abort the export process [9-46](#).

## File Naming

When you launch the Stream Data Export (SDE) dialog for a given Stream File Analysis (SFA) session for the first time, the File Path [9-43](#) and File Name [9-43](#) text boxes of the SDE dialog are populated with the respective data based on the RAM-5000 Oscilloscope

streaming data *scoBin* file, open in the active SFA session. That means, the File Path text box will show the path of the *scoBin* file, whereas the File Name text box will show the name of the *scoBin* file without the file extension.

Although you are not required to change the File Name text that is based on a *scoBin* file, it is usually best to do so to avoid generated output file naming conflicts and frequent file overwrite warnings. For example, you might want to append at least some information that reflects the currently chosen stream data export option settings. Some of these settings, like export range <sup>[9-44]</sup> and/or output file count data, is appended automatically.

**Note:** Occasionally, you might run into a situation in which the Oscilloscope user interface keeps prompting you, whether you want to overwrite existing files. This is typically the case when you have previously exported from the same RAM-5000 Oscilloscope Stream Data file (.*scoBin*) source and reused this or another previously used file name for export. Reusing the *scoBin* file *base* name, or any other previously used file name, does not necessarily cause it to be overwritten during export. However, the export process creates a separate RAM-5000 Oscilloscope settings file (.*scoSet*) by the same *base* name, which could end up being overwritten. Thus, to prevent the accidental overwriting of previously exported data and the associated *scoSet* file, the Oscilloscope user interface looks for such potential file mishaps and warns you.

- **File Path** - Use the non-editable *File Path* text box to verify the active path of the data files that will be created during export. If you wish to change the active file path, click on the small button, labeled "...", which is located next to the File Path text box, to open a dialog for browsing to and selecting another path.
- **File Browser** - Use the small button, labeled "...", located next to the File Path text box, to open a file browser for changing the output path and file name.

**Note:** If you specify a different file type in the file browser dialog, the specified file type is used to set the file search and display property, as well as the output file format <sup>[9-44]</sup>. However, if you change file type in the file browser dialog after a file name has already been selected (and is displayed in the *File name:* text box of the file browser dialog), then the file extension of the selected file name takes precedence and determines the output file format. This is done to prevent output file names with unintended extension-like file name parts that are different from the actual file format.

- **File Name** - Use the editable *File Name* text box to modify the *base* name of the data files that will be created, if you do not need to change the file path or do not want to use the file browser. Please see earlier in this help topic for additional recommendations on how to construct file names <sup>[9-43]</sup>.

**Note:** If you specify a file name extension in the *File Name* text box, intended to automatically determine the output file format, this extension will be ignored and treated like regular text as part of the file name(s) created during export. Please use the Output Format <sup>[9-44]</sup> control to specify the file content format of the created files.

## Export Range

You can specify whether to export all available Data Streams or only a certain range using the controls collectively labeled "Export Range". Using the Export Range controls you can, for example, omit from being exported waveforms that you don't really need, after inspecting the content of the RAM-5000 user interface Oscilloscope stream data file via the Stream File Analysis [\[9-40\]](#) dialog.

- **Full Range** - Use the check box control, labeled "Full Range", to force all available Data Streams to be exported. If this control is un-checked, then you can customize the range of Data Streams to export.
- **First Data Stream** - Specifies the first Data Stream of the export range. Editing this value, automatically adjusts the Last Data Stream value, offset by the Number of Data Streams setting.
- **Number of Data Streams** - Specifies the total count of Data Streams to export, starting with the Data Stream specified by First Data Stream. Editing this value, automatically adjusts the Last Data Stream value.
- **Last Data Stream** - Specifies the last Data Stream of the range to export. Editing this value, automatically adjusts the Number of Data Streams value.

## Output File Options

You can change the output file format and set various limitations for the produced file size or content using the controls collectively labeled "File Creation". Using the File Creation controls you can, for example, configure the data export process to produce a new file for each exported Data Stream or to limit the size of each created file.

The available output options are described below.

- **Output Format** - Use the drop-down menu to select one of the following options:
  - *Tab delimited text* - Produces text files with *tab* characters between channel data and consecutive streams on each line. Lines are separated by *new line* characters. A single header line provides information for each data channel and/or Data Stream, formatted like this: **{data type}{channel number}(data unit)[averaging count | Data Stream number | data acquisition timestamp]**. For example, the column header "AmpChn1(V)[Ave=2|DS=5000|08/13/2023@19:17:41.787]" would indicate that this data represents a signal amplitude waveform, measured in Volts using Oscilloscope channel 1, with an averaging count of 2, completed all waveform acquisitions belonging to this average at 19:17:41.787 on August 8, 2023, and belongs to Data Stream 5000.
  - *MATLAB Level 4* - Produces binary MATLAB data files that are limited to an array size of 100,000,000 elements. That is, each data file includes a separate matrix (each limited to no more than 100,000,000 elements --- number of points (samples) \* number

of Data Streams) for each of the available oscilloscope waveform and spectrum analyzer channels. Additionally included column-type arrays are for time and frequency data, as well as row-type arrays for averaging counts and timestamp data. For additional information on how to process MATLAB files created by the RAM-5000 Oscilloscope user interface, please see File Formats [\[9-38\]](#).

- *NI TDMS* - Produces binary data files that are structured according to the NI TDMS file format. Depending on the number of Data Streams to be saved per TDMS file, the organization into TDMS channel groups and TDMS channels per group will differ in the following way. If the number of Data Streams per file is less than or equal to 10, each Data Stream is accounted for in a separate TDMS channel group, while the TDMS channels within each group represent the various enabled Oscilloscope waveform and Spectrum Analyzer channels. If the number of Data Streams per file is greater than 10, each enabled Oscilloscope waveform and Spectrum Analyzer channel is accounted for in a separate TDMS channel group, while the TDMS channels within each group represent the total number of Data Streams per file. This particular TDMS channel groups versus TDMS channels per group organization was chosen to allow for more efficient importing into Microsoft Excel using NI's freely available TDMS Import add-on for Excel. For additional information on the TDMS format, please see File Formats [\[9-38\]](#).
  - *NI HWS* - Produces binary data files that are structured according to the NI HWS file format. For additional information on the HWS format, please see File Formats [\[9-38\]](#).
- **Output Size** - Use the drop-down menu to select one of the following options:
    - *Multiple Data Streams* - Places up to 1000 exported Data Streams into each new file. You can specify the desired value for this option using the numeric edit box, labeled "Data Streams per File [\[9-46\]](#)". The Data Stream number and total count are automatically appended to the user-specified output file name.
    - *Single Data Streams* - Produces a new file for each exported Data Stream. The Data Stream number and total count are automatically appended to the user-specified output file name.
    - *Very Small* - Limits the output file size to a maximum of 64 MB.
    - *Small* - Limits the output file size to a maximum of 128 MB.
    - *Medium* - Limits the output file size to a maximum of 256 MB.
    - *Large* - Limits the output file size to a maximum of 512 MB.
    - *Very Large* - Limits the output file size to a maximum of 1 GB.
    - *Maximum* - Limits the output file size to a maximum of 3 GB, or which ever amount of physical memory (RAM) the RAM-5000 user interface Oscilloscope add-on software module has access to.

- *Custom* - Limits the output file size to a maximum user-defined value in MB, which can be specified using the numeric edit box, labeled "Approx. Size Limit (MB)" <sup>9-46</sup>.
- Output size customization - Depending on the selected Output Size option, the numeric edit box is either labeled "Data Streams per File" or "Approx. Size Limit (MB)", and may or may not be visible or dimmed (not editable).
  - **Data Streams per File** - You can specify a custom value for the number of Data Streams per file, ranging from 2 to 1000. **Please note**, if the exported Data Streams contain multiple waveform and spectrum analyzer channels, then the actually included number of data arrays per file is larger than the here specified value. That is, the specified value is multiplied by the number of channels.
  - **Approx. Size Limit (MB)** - You can specify a custom size limit value in MB, between 1 MB and 3 GB.

## Exporting

To start exporting you click the Stream Data Export dialog button, labeled "Export".

While exporting, the button, normally labeled "Cancel" (for closing the Stream Data Export dialog box), is relabeled to "Abort". Use the Abort button to cancel data export.

Also, while exporting, the Stream Data Export dialog box is vertically enlarged to show a progress bar. Directly above this progress bar, a text line regularly updates to inform you of the overall export progress.

Depending on the chosen Output Format, it may sometimes take a several seconds for the export process to actually stop. When the export process has stopped, either because of an Abort or because it is complete, the Stream Data Export dialog reverts back to the edit state so you may chose different Export Range or File Creation settings and perform another data export session.

**Note:** Depending on the amount of data to be exported and the chosen file format, exporting may take several minutes.

When exporting data, a settings file <sup>9-5</sup> with the extension ".scoSet" is automatically created as well. This file can be used to configure the Oscilloscope user interface and hardware with the same settings used during the original Oscilloscope data streaming session.

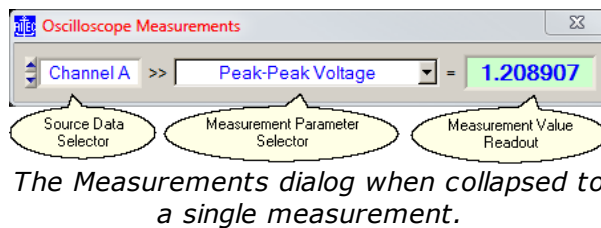
## 9.1.10 Measurements

The measurements presently implemented, include:

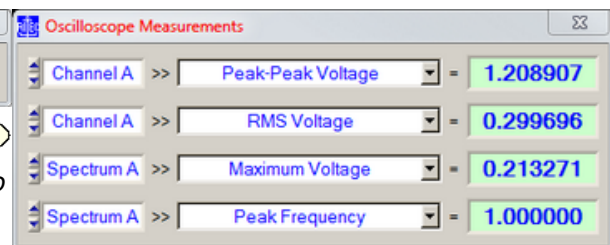
- Scalar Measurements [9-47](#)
- Measurements using Cursors [9-48](#)

When using the Spectrum Analyzer [9-34](#), you can also measure the voltage at peak frequency [9-35](#) of a spectrum and the frequency at peak voltage.

### 9.1.10.1 Scalar-type



*The Measurements dialog when collapsed to a single measurement.*



*The Measurements dialog when fully expanded and showing different types of measurements.*

You can use the Oscilloscope Measurements dialog to enable various scalar-type measurements on any of the active traces.

Up to 4 simultaneous measurement channels can be activated. To increase or decrease the number of measurement channels, you simply size the dialog window vertically using the mouse.

The **Source Data Selector** is used to select the input data for a particular measurement of interest. The drop down menu associated with this control is dynamically populated based on the available active Oscilloscope channels and the available Spectrum Analyzer channels if the Spectrum Analyzer is currently also active.

The **Measurement Parameter Selector** is used to select a measurement for the chosen Source Data, or to disable the particular measurement channel. The drop down menu associated with this control is dynamically populated with the available measurements based on the selected Source Data type, but always contains the menu item "OFF" for disabling the measurement channel.

If the input data represents RF waveforms, the following list of measurements are currently available:

- Minimum Voltage = The largest negative voltage value.
- Maximum Voltage = The largest positive voltage value.
- Mean Voltage = The calculated average value of all waveform data points.

- Peak-Peak Voltage = Maximum Voltage - Minimum Voltage.
- RMS Voltage = The traditionally calculated root-mean-square value of all waveform data points.
- AC Voltage RMS Estimate = The calculated estimation of the AC contents in volts, root-mean-square, of the waveform signal.
- DC Voltage Estimate = The calculated estimation of the DC contents in volts of the waveform signal.

If the input data represents spectra, the currently available measurements are:

- Maximum Voltage = The largest voltage value.
- Peak Frequency = Frequency value in MHz at Maximum Voltage.

The **Measurement Value Readout** continuously updates and displays the result of a certain measurement. The applicable unit can usually be inferred from the measurement label, for example, "RMS Voltage". Thus, for waveform input data this is typically unscaled volts. If the input data is a spectrum and the measurement is "Peak Frequency", the result is always displayed in MHz.

### 9.1.10.2 Cursors

The Cursors dialog allows you to set up a cursor (or a pair of cursors) for a particular graph, to manually measure simple waveform or spectrum parameters of such traces on the respective graph. Whether you will have a single cursor or a pair of cursors, depends on the type of measurement Readout <sup>9-48</sup> you select for the graph.

Although a graph maintains cursors for every possible trace or channel in the graph, each graph will only have one active cursor readout at a time displayed, even if there are multiple traces. If a graph shows more than one trace, you can switch between the associated cursors simply by changing the active edit channel (keyboard shortcut **F5**).

Each cursor has a so-called Pointer <sup>9-50</sup>, marked by a symbol, where the actual reading of the X and/or Y graph coordinate(s) takes place. If the chosen measurement readout involves a pair of cursors, you can make either cursor the active one (which affects certain Readout types, see below for more details) by left-clicking the mouse pointer on its Pointer (or close to it), or by using the **PageUp** and **PageDown** keys on your keyboard.

In the following, each item on the Cursors dialog is described in detail.

"Graph" is for selecting one of the available graphs to configure cursors for.

"Enable Cursor(s)" displays or hides the cursor(s) for the selected graph. To set a measurement Readout for the selected graph you must first enable its cursor(s).

--- Readout ---



Dependent upon for which type of graph (waveform versus spectrum) you are setting up cursors, most but not all of the following readout options are available for you to choose from:

"X Axis Absolute"  
 "X Axis Difference"  
 "X Axis Frequency"  
 "Y Axis Absolute"  
 "Y Axis Difference"  
 "Y Axis Ratio"  
 "Y Axis Ratio in %"  
 "Y Axis Ratio in dB"  
 "X & Y Axis Absolute"  
 "X & Y Axis Differences"  
 "X Axis Difference & Y Axis Ratio"  
 "X Axis Difference & Y Axis Ratio in %"  
 "X Axis Difference & Y Axis Ratio in dB"  
 "X Axis Frequency & Y Axis Difference"  
 "X Axis Frequency & Y Axis Ratio"  
 "X Axis Frequency & Y Axis Ratio in %"  
 "X Axis Frequency & Y Axis Ratio in dB"

The readouts "X Axis Difference" and "Y Axis Difference" allow you to read off absolute coordinates in addition to measuring the respective difference. For example, the Readout graph display may look like this "Ch1: X = 4.00  $\mu$ s, dX = 5.00  $\mu$ s", or like this "Ch1: dX = 5.00  $\mu$ s, X = 9.00  $\mu$ s". In the first case, the absolute X coordinate of the left cursor line is shown left, followed by the difference between the left and the right cursor line coordinates past the comma. This type of Readout is displayed when the left cursor is the active one (indicated by a thick line). If the right cursor would be the active one, the second type of Readout would be displayed, in which the difference between the left and the right cursor line coordinates is shown left, followed by the absolute X coordinate of the right cursor line past the comma. This conveniently allows you to read off absolute coordinate values of either cursor in addition to the primary readout parameter, simply by switching the active cursor.

You can reposition a Readout display anywhere on the graph, simply by dragging it with the mouse pointer to another location.

### --- Options ---

"Snap to nearest data point" causes a cursor's pointer location to always coincide with a data point, if enabled. This option is particularly useful to semi-automate certain measurements, as the cursor basically tracks a selected data point, and the Readout continuously reflects the data point's actual X and/or Y coordinate(s). Enabling this option automatically disables the option "Secondary tracks Primary", as both options are mutually exclusive in operation.

"Secondary tracks Primary" causes the lower and/or right cursor line(s) to be tracking the upper and/or left cursor line(s) when moving the latter, if enabled for a two-cursor type of Readout. You set the tracking distance by moving the lower and/or right cursor line(s) to a new location relative to the upper and/or left cursor line(s). Enabling this option automatically disables the option "Snap to nearest data point", as both options are mutually exclusive in operation.

"Pointer Style" is for customizing the symbol that marks the cursor pointer location. Even though a cursor may only be a horizontal or a vertical line, its pointer is nevertheless visible and is used when dragging the cursor with the mouse and for reading the X and/or Y graph coordinate(s) below it.

"Cursor Color" is for customizing the color of the graph's cursor.

# Section 10

---

*Instrument API*

## 10 Instrument API

This section contains information on how to program the RAM-5000-M6-Plus using the provided instrument control and data acquisition API (Application Programming Interface).

The RAM-5000-M6-Plus 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 1.1.11 (October 2023)

# Section 11

---

*Theory of Operation*

# 11 Theory of Operation

The following sections discuss in detail the theory of operation of the RAM-5000-M6-Plus system:

- Signal Processing <sup>[11-2]</sup>
- Superheterodyne Receiver and Phase-Sensitive Detector <sup>[11-3]</sup>
- Analog Integration <sup>[11-4]</sup>
- Reduction of Measurement Errors <sup>[11-7]</sup>

## 11.1 Signal Processing

Figure 11-1 shows the block diagram of the instrumentation approach used in the RAM-5000-M6-Plus system.

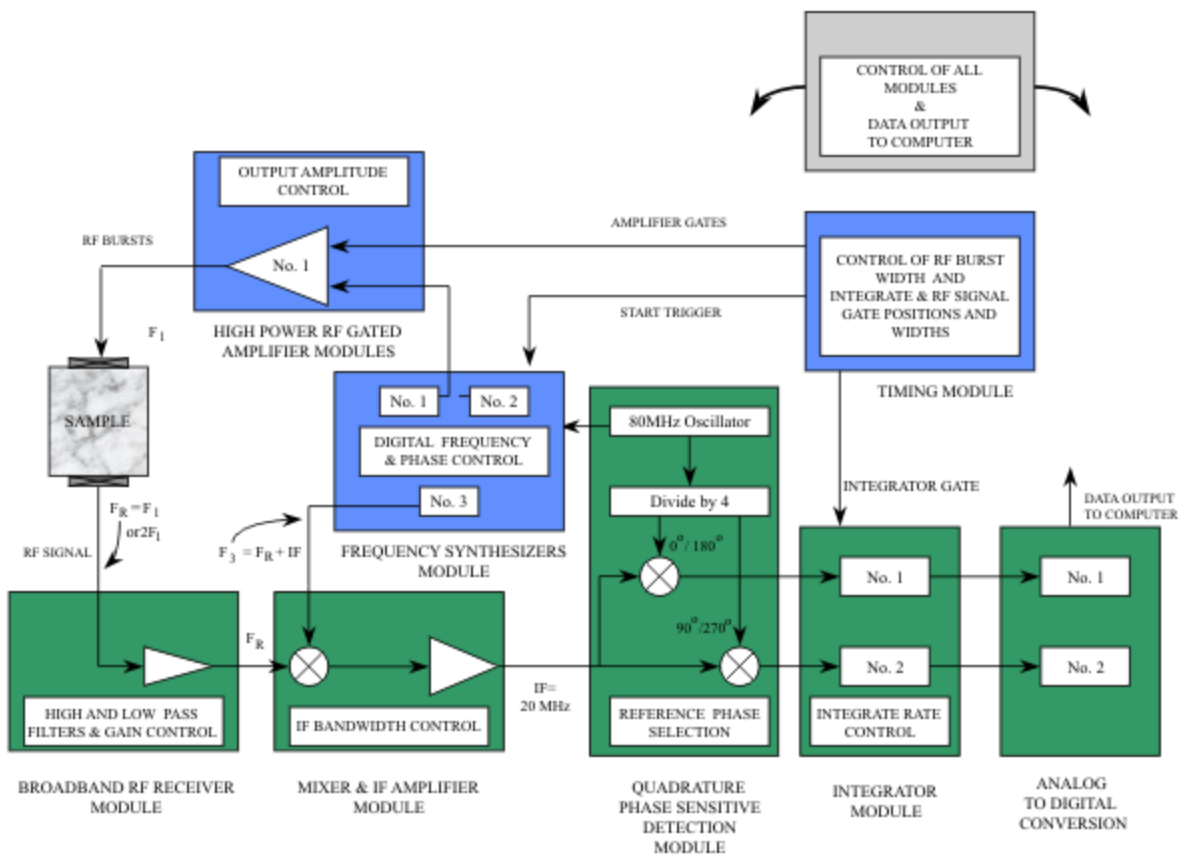


Figure 11-1. Block diagram of RAM system.

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:

$$\text{Transmit Signal} = A_{S1} \cos(2\pi F_{S1} t), \quad (11-1)$$

where  $t$  is taken as zero at the beginning of each burst where the synthesizers are turned on.

## 11.2 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).

$$V_{S3} = A_{S3} \sin(2\pi(IF + F_r)t) \quad (11-2)$$

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:

$$f(t) = A_r(t) \sin(2\pi F_r t + \phi_r) \quad (11-3)$$

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 in the mixer by the synthesizer output, the resulting voltage is given by:

$$V_{Mixer} = g_2 A_r(t) \cos(2\pi IFt - \phi_r) + High\ Freq.Term \quad (11-4)$$

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 11-4 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:

$$Reference_{0^\circ} = A_{Ref} \sin(2\pi IFt) \quad (11-5)$$

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:

$$PhaseDet.No.1 = g_3 A_r(t) \sin \phi_r + High\ Freq.Term \quad (11-6)$$

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:

$$PhaseDet.No.2 = g_3 A_r(t) \cos \phi_r + High\ Freq.Term \quad (11-7)$$

Equations 11-5, 11-6, and 11-7 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 11-1) 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.

### 11.3 Analog Integration

If the high frequency terms of Equations 11-6 and 11-7 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 11-2. 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.

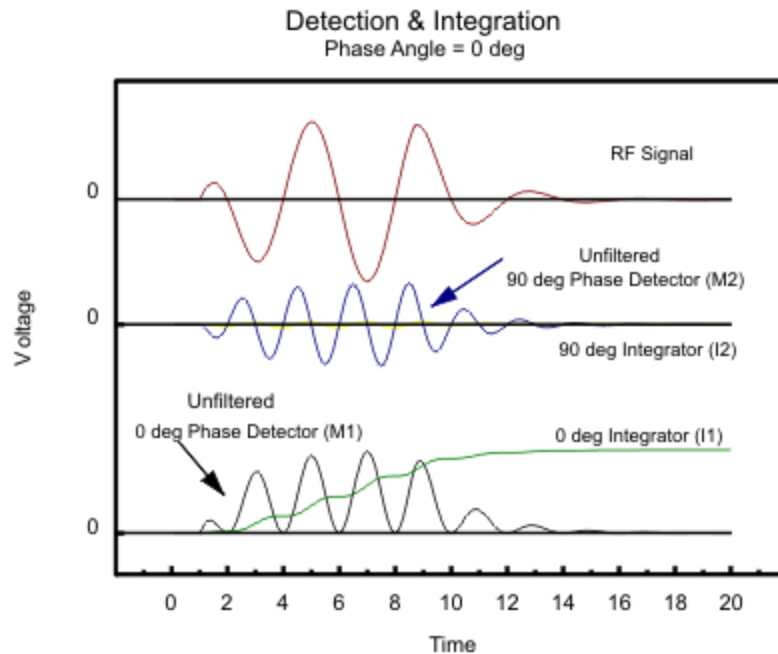


Figure 11-2. RF Receiver, Quadrature Phase Sensitive Detector, and Integrator Outputs for a typical signal with  $\phi_r = 0^\circ$ .

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 11-2, 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 11-3.

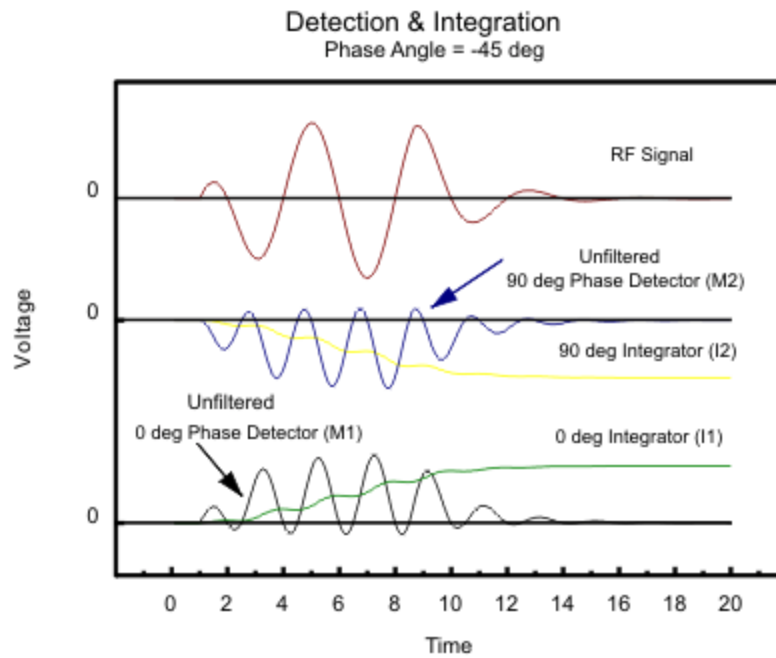


Figure 11-3. RF Receiver, Quadrature Phase Sensitive Detector, and Integrator Outputs for a typical signal with  $\phi_r = -45^\circ$ .

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:

$$I_1 = r_I g_3 \cos \phi_r \int_{t_1}^{t_2} A_r(t) dt \tag{11-8}$$

$$I_2 = r_I g_3 \sin \phi_r \int_{t_1}^{t_2} A_r(t) dt \tag{11-9}$$

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:

$$\phi_r = \tan^{-1} \left( \frac{I_2}{I_1} \right) \tag{11-10}$$

Notice that in Figure 11-3,  $I_1$  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.

## 11.4 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 (shifting by 180°) the electrical phases of the "in-phase" and "quadrature" RF reference 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 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 procedures or removed by averaging.

---

1. H.J. McSkimin, In *Physical Acoustics*, Vol. IA, W.P. Mason ed (Academic Press, New York, 1964), pp. 27-417.

# Section 12

---

*Instrument Connectors*

## 12 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 [12-2](#)
- Rear Panel BNCs [12-3](#)

### 12.1 Front Panel Connectors

This section describes the instrument connectors that are located on the front panel of the RAM-5000-M6-Plus.

- RF BURST HIGH POWER OUT [12-2](#)
- RF BURST MONITOR [12-2](#)
- RECEIVER INPUT NO.1 [12-3](#)
- RECEIVER INPUT NO.2 [12-3](#)
- RECEIVER RF MONITOR [12-3](#)

#### 12.1.1 RF BURST 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.

#### 12.1.2 RF BURST 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 [12-2](#) 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.

### 12.1.3 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.

### 12.1.4 RECEIVER INPUT NO.2

**Impedance: 50 Ohm**

Receiver input channel No.2.



Otherwise, same as for RECEIVER INPUT NO.1 .

### 12.1.5 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  channels is about 32 dB less than the total receiver gain specified by the Gain  control.

## 12.2 Rear Panel Connectors

This section describes the instrument connectors that are located on the rear panel of the RAM-5000-M6-Plus.

- SIGNAL OUT 1 [12-4](#)
- SIGNAL OUT 2 [12-4](#)
- SIGNAL OUT 3 [12-4](#)
- SIGNAL OUT 4 [12-4](#)
- GA PRE-GATE MON
- TRIGGER IN [12-8](#)
- TRIGGER OUT [12-8](#)

### 12.2.1 SIGNAL OUT 1, 2, 3, 4

#### **Impedance: 50 Ohms**

There are multiple signals that can be monitored in a RAM-5000-M6-Plus system. Your system is equipped with a software-controllable signal monitor multiplexer. The primary function of this multiplexer is to simplify the operation of the RAM-5000-M6-Plus system by eliminating the need to frequently change cables to monitor signals using an oscilloscope.

Each of the rear panel BNC connectors labeled, **Signal Out 1**, **Signal Out 2**, **Signal Out 3**, and **Signal Out 4**, may be configured [12-6](#) independently to monitor any of the following signals (actual availability depends on RAM-5000 system configuration)

- **Trigger**  
Same as dedicated BNC TRIGGER OUT [12-8](#).
- **Synthesizer**  
Monitors the gated RF Burst signal at the low-level stage before entering the respective Gated Amplifier for high-power amplification.  
  
When using modulation [4-12](#) in the *Combine* mode, ...?  
  
When using modulation in the *Hanning* mode, ...?
- **Synthesizer 3**  
Monitors the local oscillator frequency, which is the detector frequency [5-5](#) plus 20 MHz (IF), as shown in the block diagram [11-2](#).
- **RF Burst**  
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 [12-2](#) 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.

The signal output is identical to the output at the respective dedicated RF BURST MONITOR [12-2](#) on the front panel of the instrument, if your RAM-5000-M6-Plus is fitted accordingly.

- **RF Receiver**

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 [12-3](#) channels is about 12 dB less than the total receiver gain specified by the Gain [5-4](#) control.

The signal output is similar to the output at the dedicated RECEIVER RF MONITOR [12-3](#) on the front panel of the instrument.

- **Phase Detector 1 and 2**

To check character and amplitude of a phase detected signal.

Both signals, the in-phase signal (Detector 1) and the 90-degrees out-of-phase signal (Detector 2), should not exceed 200 mV at this monitor point which corresponds to a 2 Volt signal within the system.

- **Integrator Gate**

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.

- **Integrator 1 and 2**

For observation of the integration waveform of the respective Gated Integrator at -20dB.

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.

- **Auxiliary**

This can be configured at Ritec for other RAM-5000 signals that are not normally brought out, such as the IF signal monitor.


Alternatively, this line can be routed to a dedicated BNC on the rear panel of the instrument, and the user can input his own signal to be monitored or used for signal processing any of the RAM-5000 signals. The input is limited to a maximum of +/-5 Volts.

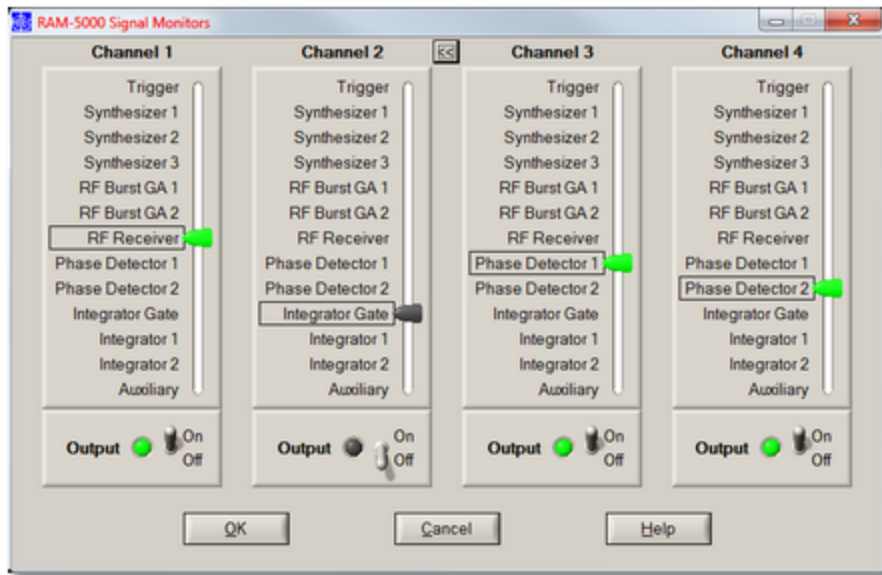
### ***RAM-5000 Signal Output channels default configuration***

The factory default configuration of the 4 signal outputs is as follows:

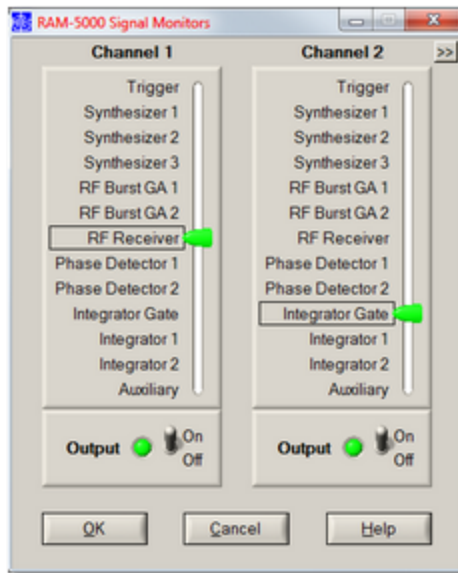
- Signal Out 1 = RF Burst 1 monitor at -60dB
- Signal Out 2 = **RF Receiver** output monitor
- Signal Out 3 = **Phase Detector 1** monitor
- Signal Out 4 = **Integrator Gate** monitor

### ***RAM-5000 Signal Monitors dialog***

To reconfigure each of the 4 signal output channels, you use the *RAM-5000 Signal Monitors* dialog, shown below, which can be launched from the Tools menu .



The Signal Monitors dialog, shown here for a RAM-5000-SNAP system configuration.



The Signal Monitors dialog for a SNAP system when using a 2 channel oscilloscope.

On the Signal Monitors panel, the controls below label **Channel 1** are used to control the output signal for the RAM-5000 rear panel BNC connector, labeled **Signal Out 1** . Likewise, the controls below dialog labels **Channel 2**, **Channel 3**, and **Channel 4** are used to control the output signals for **Signal Out 2**, **3**, and **4**, respectively.

When using an oscilloscope with 2 channels, you can reduce the Signal Monitors panel to show only **Channel1** and **Channel 2**. To alternate the panel width between full size and half size, you click on the small button, labeled either "<<" or ">>" depending on panel width, that is located to the right of the "Channel 2" label.

To change the monitored signal for a certain output channel, you simply move the corresponding slider up or down, or click on a particular signal label, such as "RF Receiver".

To enable or disable the channel output, you use the On/Off switch below the signal slider.

Operating either of these controls, that is, the Signal slider or the On/Off switch, will have immediate effect on the output for the respective channel.

When you click the Ok button the dialog simply closes and the settings are stored. You can revert back to the active signal output setup when the dialog was opened by clicking the Cancel button and then confirming that action.

### 12.2.2 TRIGGER OUT

***Impedance: 50 Ohms***

Positive (5 V) trigger that is coherent with the RF tone burst from the gated amplifier.

### 12.2.3 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 <sup>(12-8)</sup> connector.

# Section 13

---

*System Checks*

## 13 System Checks

Several internal system diagnostic procedures may be initiated from the System Checks control panel to verify that the RAM-5000-M6-Plus is working properly.

For example, to check communication with the RAM-5000-M6-Plus, you can view the power supply voltages in the instrument by selecting the tab labeled "Power Supply Voltages".

- Power Supply Voltages  13-21

### 13.1 Power Supply Voltages

Pressing the button labeled "Check" will initiate an internal diagnostics procedure to produce voltage readings for the various power supplies.





# **Section 14**

---

*Appendices*

## 14 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](#) 
- [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*)
- [Controlling the RAM-5000 via USB](#) 
- [External Power Output Connectors](#) 
- [Specifications](#) (click to open or see *SPECIFICATIONS.pdf*)
- [Warranty](#) 

### **Application Notes:**

- [SNAP System](#) (click to open or see *SNAP\_Info.pdf*)

## 14.1 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.



## 14.2 Controlling the RAM-5000-M6-Plus via USB

**Note:** This section assumes that the RAM-5000-M6-Plus 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 <sup>14-2</sup>

With certain limitations, you can control and acquire data with the RAM-5000-M6-Plus also through a USB connection. This section describes how to connect to and operate the RAM-5000-M6-Plus via USB.

Although the RAM-5000-M6-Plus 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-M6-Plus 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-M6-Plus 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-M6-Plus 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-M6-Plus. 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-M6-Plus instrument control over a USB connection:***

1. Install the Sealevel SeaMAX software drivers on the RAM-5000-M6-Plus 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-M6-Plus.
3. Connect the Sealevel 8126 USB module to the RAM-5000-M6-Plus using a 50-conductor ribbon cable similar to the one supplied with the 8010.

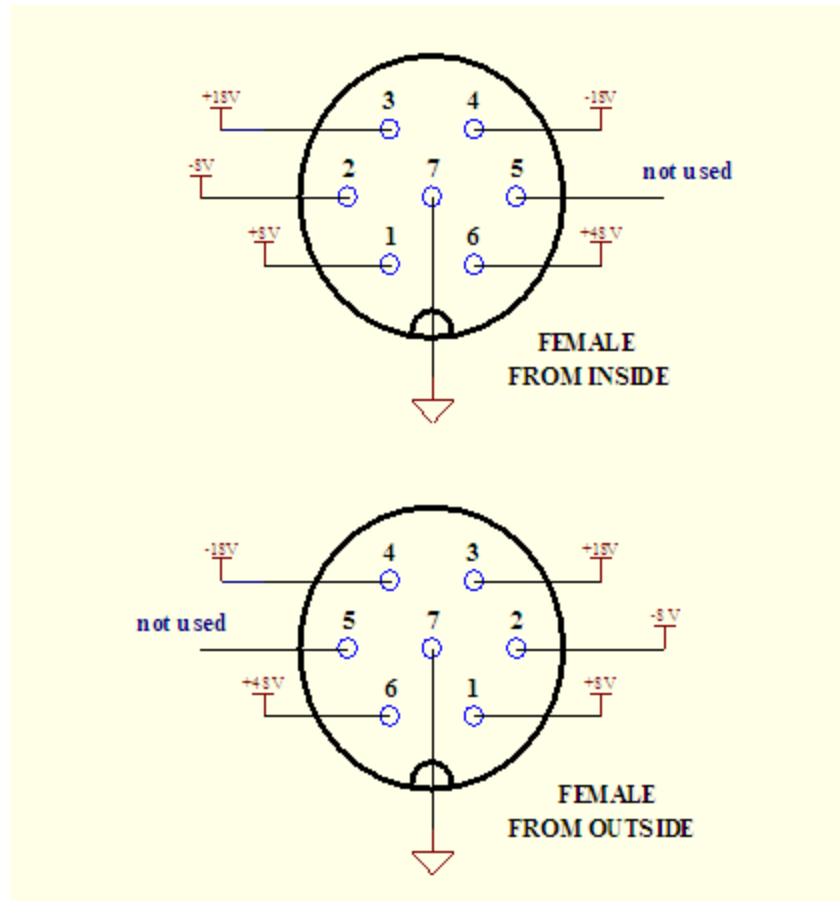
4. Connect the Sealevel 8126 USB module to the control computer using a USB device cable.
5. Verify that the 8126 is detected as such by the operating system. - Open the Device Manager and look for Sealevel 8126.
6. Launch the RAM-5000-M6-Plus User Interface as you normally would. - If the RAM-5000-M6-Plus User Interface successfully initialized I/O via the USB connection, the title bar will read "RAM-5000-M6-Plus (USB)".

***How to disable an existing USB connection:***

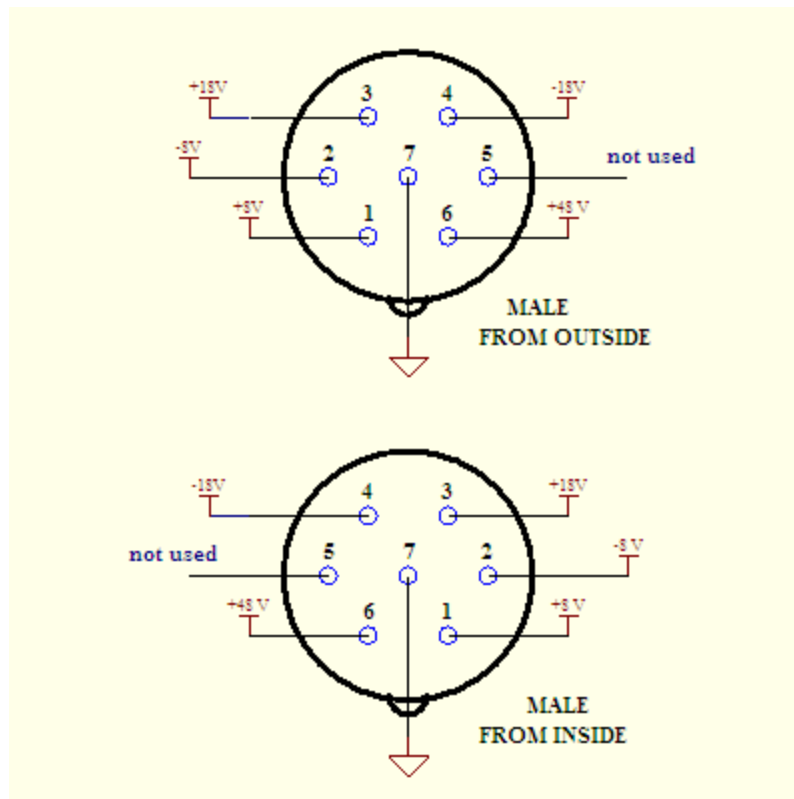
1. If applicable, shut down the RAM-5000-M6-Plus User Interface as you normally would.
2. Unplug either end of the USB device cable that connects the Sealevel 8126 USB module to the control computer.
3. Unplug the ribbon cable from the RAM-5000-M6-Plus that connects to the Sealevel 8126 USB module.
4. Insert the ribbon cable coming from the Sealevel 8010 interface inside the control computer into the RAM-5000-M6-Plus.
5. Launch the RAM-5000-M6-Plus User Interface as you normally would. - If the RAM-5000-M6-Plus User Interface successfully initialized I/O via the 8010 interface, the title bar will not show anything in parentheses.

### 14.3 External Power Output Connectors

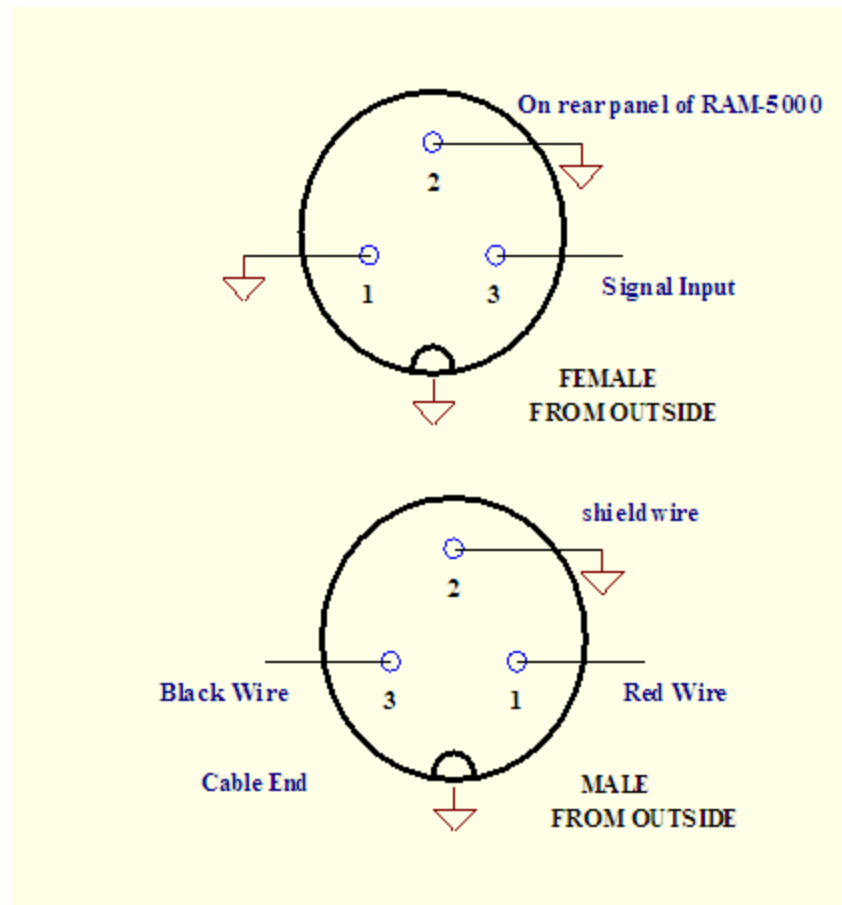
There is a pair of auxiliary power connectors located on the rear panel of the RAM-5000 instrument to power peripherals such as a clamped diplexer or preamplifier. For safety reasons, the connectors on the instrument are female polarity. With a powered peripheral, we will supply a 7-pin connector with 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:



## 14.4 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.

# Index

▪

.scoBin file 9-40

## A

accessing measurements 9-6

acquisition

auxiliary A/D 6-33

averaging 9-26

background data 6-17

burst counter 6-22

complete cycle 6-3

control panel 6-3, 9-26

data logging 6-6

filtering 9-27

initiating 6-22

making measurements 8-2

measurement rate 6-5

mode 9-28

run mode 6-20

scanning 6-8, 7-18

trigger controls 6-4

trigger source 6-4

user interface 6-2

acquisition controls

averaging count 9-26

averaging enable 9-26

filter enable 9-27

filter frequency cutoff 9-28

filter frequency type 9-28

filter type 9-27

Run Mode 9-28

Run/Stop 9-28

acquisition mode

phase sensitive 6-24

waveform FFT 6-24

acquisition speed 9-32

Acquisition tab 6-23

active gated amplifier 4-9

ADC bits 9-29

ADC resolution 9-29

add-on modules

oscilloscope 9-2

amplitude control

modulation signal 4-23

synthesizer 4-6

analog

data displays 7-6

API 10-2

appendices 14-2

application notes 14-2

aspect ratio 7-12

attenuation

relative measurement overview 8-6

relative measurement setup 8-8

relative measurement theory 8-6

auxiliary power connectors 14-6

auxiliary

A/D channel 6-33

A/D setup 6-34

gauges 7-6, 7-7

averaging 9-26

continuous 9-26

mean 6-26, 9-27

mode 6-26

running 6-27

summed 9-27

averaging count 9-26

## B

background 6-17

acquisition mode 6-15

acquisition setup 6-17

data handling 6-17

bandwidth 9-30

BNC

front panel 12-2

rear panel 12-3

receiver input 12-3

receiver RF monitor 12-3

RF pulse monitor 12-2

RF pulse output 12-2

trigger input 12-8

trigger output 12-8

universal signal monitors 12-4

burst

amplitude 4-6, 4-7

cycles 4-3

delay 4-5

- burst
  - frequency 4-3
  - phase 4-5
  - width 4-3
  - width mode 4-4
- burst rep-rate 4-29

## C

- calibration
  - DC offset control 4-25
- channel
  - auxilliary A/D 6-33
  - receiver input 5-3
- channel equalization 9-17
- channel input coupling 9-17
- channel locking 9-17
- channel selector 9-9
  - trace properties 9-9
- common view controls 7-23
- continuous averaging 9-26
- coupling 9-17
- cursor
  - color 9-50
  - pointer style 9-50
  - readout 9-48
  - snapping to data points 9-50
  - tracking of primary 9-50
- cycles per burst 4-3

## D

- data
  - saving 9-5
  - streaming 9-5
- data acquisition 9-26
- data buffer
  - AB graph 7-12
  - strip charts 7-9
  - table view 7-16
- data display
  - A versus B graph 7-11
  - meters 7-5
  - parametric 7-11
  - strip charts 7-8
  - table format 7-15
  - with history 7-8

- data logging 6-6
  - log file format 6-7
- data storage 9-38
- data table 7-16
- data view 7-23
- DC offset 9-17
- DC offset control 4-24
  - calibrated use 4-24
- DC offset control calibration 4-25
- delay
  - amplifier gate 4-5
  - integrator gate 5-9
- delay control (X-Magnification) 9-22
- desktop confinement 3-10
- detector controls
  - RF waveform FFT 5-10
  - superheterodyne 5-5
- differential 6-25
- digital
  - data displays 7-6, 7-7
- digitizer
  - controls 5-15
- Digitizer tab
  - horizontal controls 5-16
  - oscilloscope UI integration 5-15
  - signal conditioning 5-17
  - trigger controls 5-16
  - vertical controls 5-16
- display options 9-8
  - graph properties 9-8
  - trace properties 9-8
- duty cycle 4-29

## E

- edge triggering 9-24
- Equivalent Time Sampling 9-29
- error reduction 11-7
- ETS 9-29
- exit
  - user interface application 3-5, 9-6
- exit confirmation 3-10
- external acquisition rate 6-6
- external trigger rate 4-30



**F**

- FFT 9-34
- FFT Detector 5-10
  - Data Scaling 6-26
  - enhanced resolution 5-11
  - frequency 5-12
  - Oscilloscope Channel 6-26
  - preview settings in spectrum analyzer 5-12
  - resolution indicator 5-11, 5-12
  - RF waveform gate 5-11
  - standard resolution 5-11, 5-12
  - tracking 5-13
  - tracking frequency 5-14
  - tracking source 5-13
  - window function 5-10
  - window type 5-10
- FFT resolution
  - enhancement 5-11, 5-12
  - frequency step 5-11
  - frequency stepkeyword1 5-12
  - sub keyword1 5-12
- file formats 9-38
- File menu 3-4, 9-5
- filter
  - IF band-pass 5-8
  - RF high-pass 5-3
  - RF low-pass 5-4
  - Video low-pass 5-8
- filter settings (Acquisition)
  - order 9-30
  - passband ripple 9-30
  - stopband attenuation 9-31
  - type 9-30
- filtering 9-27
- filtering options 9-30
- frequency
  - burst 4-3
  - detector 5-5
  - FFT Detector 5-12
- full-scale control 9-16

**G**

- gain 5-4
- gain control 9-15

- general setup 9-13
- getting started
  - overview 2-2
- graph properties 9-8
  - background color 9-8
- graph view
  - A versus B 7-11

**H**

- Help menu 3-9, 9-7
- horizontal oscilloscope settings 9-18

**I**

- IIR filter types 9-30
- IIR Filters 9-28
- initiating acquisition 6-22
- input
  - auxilliary A/D channel 6-33
  - receiver channel 5-3
  - receiver input enable 5-3
  - trigger signal 12-8
- input channels 9-13
- input coupling 9-17
- input signal selector 9-13
- installation
  - computer interface 14-2
  - connectors 12-2
  - initial setup 2-3
  - instrument 2-2
- instrument
  - overview 1-2
- instrument API 10-2
- integrator gate indicator 9-13
- integrators
  - gate delay 5-9
  - gate width 5-9
  - integration rate 5-9
  - integrator controls 5-9

**K**

- keyboard shortcut
  - F5 9-9
  - F9 9-28
- keyword2

keyword2  
 sub keyword2 5-12

## L

level control  
 gated amplifier bias 4-9  
 gated amplifier output 4-7  
 gated amplifier RF 4-8  
 synthesizer 4-6

loading  
 instrument setup 3-4  
 scan data 3-4  
 shortcuts 3-14

## M

magnify control (X-Magnification) 9-22

mean averaging 9-27

measurement  
 accessing measurements 3-5  
 error reduction 11-7  
 implemented 8-2  
 overview 8-2  
 readout 9-48  
 time-of-flight 8-2, 8-3, 8-5  
 measurements 9-47  
 cursors 9-48  
 nonlinear parameters 8-12, 8-14  
 relative 8-6, 8-8  
 scalar 9-47

Measurements menu 9-6

menu  
 File 3-4  
 Help 3-9  
 main menu 3-3, 9-4  
 Measurements 3-5  
 Options 3-7  
 Tools 3-6  
 Window 3-8

menus  
 File menu 9-5  
 Help menu 9-7  
 Measurements menu 9-6  
 Options menu 9-6  
 Tools menu 9-6  
 Window menu 9-7

meters view 7-5  
 modulation  
 amplitude 4-23  
 Combine 4-14  
 Combine operation 4-17  
 controls 4-10  
 DC offset 4-24  
 DC offset control calibrated 4-24  
 DC offset control calibration 4-25  
 dialog when changing type 4-19  
 Hanning 4-15  
 Hanning operation 4-18  
 ratio between amplitudes 4-23  
 types of modulation 4-12  
 modules 9-2  
 multi-frequency  
 tracking setup dialog 6-29  
 tracking signal configuration 6-28

## N

narrowband receiver section 5-5

nonlinear  
 simple measurements 8-12

nonlinear parameters  
 measurement setup 8-14

NOTE: To reinclude this topic (with subsections!) for html help, check the custom build variables "HTML Help" (5-16-2010) 9-2

NOTE: To reinclude this topic (without subsections!) for print/pdf, check the custom build variables "Print Manual" and "PDF Export" (5-16-2010) 9-2

## O

offset voltage 9-17  
 Options menu 3-7, 9-6  
 oscilloscope 9-2  
 acquisition 9-26  
 graph 9-8  
 horizontal settings 9-18  
 input signal 9-13  
 measurements 9-47  
 signal processing 9-26  
 signal processing options 9-28  
 spectrum analysis 9-34  
 stream data export 9-42  
 stream file analysis 9-40

- oscilloscope 9-2
  - trigger settings 9-24
  - user interface 9-4
  - vertical settings 9-15
- Oscilloscope tab
  - oscilloscope UI integration 7-3
- output
  - active 4-9
  - enable 4-9
- output control 4-7
- overview 9-3
  - data acquisition 6-2
  - measurements 8-2
  - user interface 3-2, 9-4

## P

- parametric
  - data display 7-11
- phase
  - burst source 4-5
  - detector 5-8
  - quadrature reference 6-25
- phase data
  - display format 3-10
  - frequency scanning 3-10
  - saved format 3-15
  - unwrapping 3-15
- phase sensitive 6-24
- plot 7-12
- plot axis 7-25
- plot range
  - plot properties dialog 7-26
  - single axis dialog 7-25
- post-trigger delay 9-24
- power supply check 13-2
- preferences
  - desktop confinement 3-10
  - overview 3-10
  - panel activation 3-10
  - phase data and frequency scanning 3-10
  - phase data display 3-10
  - phase data saving 3-15
  - scan data file handling 3-10
  - shortcut keys 3-12
  - standard deviation data 3-15
  - UI exit confirmation 3-10
  - UI panel scrolling & resizing 3-10

- user interface 3-10
- properties
  - axis 7-25
  - plot 7-26
- pulse rep-rate 4-29

## Q

- quadrature mode 6-25

## R

- RAM gate channel 9-13
- receiver
  - channel 5-3
  - control panel 5-2
  - detector phase 5-8
  - frequency 5-5
  - gain 5-4
  - IF band-pass 5-8
  - input controls 5-3
  - input enable 5-3
  - integration rate 5-9
  - integrator delay 5-9
  - integrator width 5-9
  - quadrature phase 6-25
  - RF high-pass 5-3
  - RF low-pass 5-4
  - tracking 5-6
  - tracking frequency 5-7
  - tracking source 5-6
  - video low-pass 5-8
- receiver RF amplifier 5-3
- relative measurements 8-6
- resetting
  - shortcut keys 3-14
- resolution 9-29
- reverse scanning 6-14
- RUN 6-22, 9-28
- run mode 6-20

## S

- samples control 9-20
- sampling options 9-29
- sampling rate control 9-21
- sampling rate fixing 9-21

- saving
  - instrument setup 3-4
  - scan data 3-4
  - shortcuts 3-14
- saving data 9-38
- scanned synthesizer 6-12
- scanning 7-18
  - burst delay 6-10
  - custom 6-11
  - data file format 6-14
  - data file handling 3-10
  - features 6-8
  - frequency 6-9
  - gated amplifier output level 6-10
  - in reverse 6-14
  - increment 6-13
  - integrator 6-10
  - number of points 6-13
  - overview 6-8, 7-18
  - phase 6-10
  - phase data handling 3-15
  - scan panel features 7-18
  - scan range 6-13
  - scan types 6-8
  - scanned synthesizer 6-12
  - synthesizer output level 6-10
  - time 6-10
  - user-defined 6-11
  - viewing data 7-20
- setting
  - keyboard shortcuts 3-12
- settings
  - saving and loading 9-5
- Set-To-Set variables 6-31
- shortcut assignments
  - viewing 3-13
- shortcut keys 3-12
  - resetting 3-14
- shortcuts
  - loading 3-14
  - saving 3-14
- shutdown
  - user interface 3-5, 9-6
- signal input coupling 9-17
- signal monitor selector dialog 12-6
- signal monitors 12-2
- signal out 1-4 defaults 12-6
- signal processing 9-26
  - signal processing options 9-28
- Signal Sets
  - setting active 6-32
- signal setups
  - data view 7-24
  - disabling for acquisition 6-33
  - managing 6-30
  - Set-To-Set variables 6-31
- signal source
  - gated amplifier controls 4-6
  - main control panel 4-2
  - modulation controls 4-10
  - synthesizer controls 4-2
  - trigger controls 4-27
- single trigger 4-29
- specifications 14-2
- spectrum analyzer 9-34
  - automatic scaling 9-35
  - base unit 9-35
  - channel enable 9-34
  - channel selection 9-34
  - controls 9-34
  - dynamic range 9-36
  - graph 9-36
  - logarithmic scaling 9-36
  - maximum voltage 9-35
  - window type 9-35
- speed optimization 9-32
- standard deviation data 3-15
- START 6-22
- step size
  - control panel 3-17
  - manual control 3-18
  - smart auto-control 3-18
- STOP 6-22, 9-28
- stream data
  - canceling export 9-46
  - exporting 9-46
- stream data export
  - Approximate File Size in MB 9-46
  - changing output path 9-42
  - Data Streams per File 9-46
  - file browser 9-43
  - file name 9-43
  - file naming 9-42
  - file naming recommendations 9-43
  - file path 9-43
  - first data stream 9-44

- stream data export
  - full range 9-44
  - last data stream 9-44
  - number of data streams 9-44
  - output file options 9-44
  - output file size 9-44, 9-45
  - output format 9-44
  - setting file size limit 9-44
  - single data streams 9-44

- stream files
  - analysis 9-40
  - data export 9-42
  - file control 9-40
  - file info 9-41
  - opening 9-40
  - stream block 9-41
  - viewing 9-40
  - waveform retrieval 9-41
  - waveform selection 9-41

- streaming 9-39

- streaming options 9-31
  - RAM averaging 9-31
  - RAM-controlled 9-31

- strip chart view 7-8

- summed averaging 9-27

- synthesizer amplitude 4-6

- system checks 13-2

## T

- table view 7-15

- theory 8-6, 11-3

- analog integration 11-4

- error reduction 11-7

- instrument signal processing 11-2

- instrument theory TOC 11-2

- parameter of nonlinearity beta 8-12

- phase-sensitive detection 11-3

- relative attenuation measurement 8-6

- relative transit time measurement 8-6

- superheterodyne receiver 11-3

- transit time measurement 8-3

- time history 7-9

- time width control 9-19

- timebase control 9-18

- time-of-flight

- measurement dialog 8-5

- measurement overview 8-2

- measurement theory 8-3

- Tools menu 3-6, 9-6

- trace properties 9-8

- color 9-9

- plot style 9-8

- point style 9-8

- tracking

- data view 7-24

- frequency 5-7

- multi-frequency 6-28, 6-29

- source 5-6

- transducer cautionary 14-3

- transit time

- measurement dialog 8-5

- measurement overview 8-2

- measurement theory 8-3

- trigger

- acquisition counter 6-22

- acquisition rate 6-5

- acquisition trigger source 6-4

- data acquisition 6-4

- external DAQ rate monitor 6-6

- external rep-rate monitor 4-30

- input connector 12-8

- output connector 12-8

- rep-rate 4-29

- single burst 4-29

- source selection 4-28

- trigger controls 4-27

- trigger settings 9-24

- delay 9-24

- level 9-25

- slope 9-24

- source 9-24

- trigger type 9-24

- edge 9-24

## U

- USB Interface 14-4

- user interface

- controls 9-10

- customizing 3-3, 9-4

- instrument controls 3-16

- menu controls 3-16, 9-10

- numeric controls 3-17, 9-11

- overview 3-2

- setting preferences 3-10

## V

- variable gain control 9-16
- variable gain mode 9-15
- variable time base mode 9-19
- vertical oscilloscope settings 9-15
- viewing
  - shortcut assignments 3-13

## W

- warranty 14-9
- waveform
  - gating 5-11
- waveform FFT 6-24
- waveform gate
  - delay 5-11
  - width 5-11
- waveforms
  - digitization 5-15
- window
  - FFT Detector 5-10
  - FFT window 5-10
  - RF waveform 5-10
- Window menu 3-8, 9-7

## X

- X-grid labels 9-20

## Y

- Y-grid labels 9-16

## Z

- zooming
  - X-Magnification 9-22