



Advanced Measurement System

RAM-5000-M4-Plus

User Guide

Version 1.1.2 Rev.0

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Section 1

Instrument

1 Instrument

This chapter describes the RAM-5000-M4-Plus hardware in detail.

- Power Frame [1-2](#)
- Synthesizer [1-3](#)
- Gated Amplifier [1-5](#)
- Broadband Receiver [1-7](#)
- Connectors and Monitors [1-8](#)

1.1 Power Frame

The RAM-5000 Power Frame (model number PF-5000) is the platform on which all RAM-5000 configurations are built.

The PF-5000 is a versatile platform, with eleven (11) available module slots. These slots can be configured to accept any number of module combinations.

Currently Available Modules

- RM-116 Triple Synthesizer
- RM-145 Gated RF Amplifier (2 slots per module)
- RM-132 Signal Modulator
- RM-25 Broadband Receiver
- RM-24 Mixer and IF Amplifier
- RM-55 Phase Sensitive Detectors
- RM-106 Dual Gated Integrators

Custom modules may be available. Please contact Ritec, Inc. for more details.

In addition to housing the modules which make up the RAM-5000 series instrument, the PF-5000 handles a number of functions itself.

Measurement Circuits

The PF-5000 incorporates a number of measurement circuits to communicate data from various inputs, both internal and external, to the computer and software control interface. The following measurement circuits are incorporated in to the PF-5000.

Integrator Analog-to-Digital Converters	2
Resolution (self-calibrating)	16-bits

Multi-Purpose Analog-to-Digital Converter	1
Resolution	12-bits
Multiplexed Inputs	8
External Sensor Inputs	2
Maximum Input Level	+/- 5V

Communications

The RAM-5000 is a computer controlled instrument. Communications to the computer are made through a Digital I/O interface. The hardware specifications for this interface are as listed below.

Digital Interface	32-bit TTL (16-bit Input, 16-bit Output)
Communication Card	Sealevel 8001 (PCI)
Interface Connector	D-37 Cable with Gender Changer

Power

The PF-5000 Power Frame features a Universal AC Input Power Supply. In addition to powering the internal modules, two (2) auxiliary power outputs are provided on the rear panel of the unit for use with powered accessories. The power specifications are as listed below.

AC Power Requirement	85-240 VRMS, 50-60 Hz
AC Power Consumption	~300 Watts
AC Power Factor	>99%
Auxillary Power Outputs (x2)	(-18V, -8V, +8V, +18V, +48V)

1.2 Synthesizer

The Synthesizer in the RAM-5000 (currently the RM-116 Triple Synthesizer Module) is responsible for two (2) distinct functions; signal generation and timing.

Signal Generation

The Synthesizer provides RF Signals, as well as the required Gate Functions with which to drive the Gated RF Amplifiers ⁽¹⁻⁵⁾.

The current RM-116 Triple Synthesizer is a three channel synthesizer. For each synthesizer channel, three individual signals are produced and output to the Gated RF Amplifier.

- An RF Signal Source is produced. This is a RF signal of a defined, single frequency as controlled by the user [3-3].
- An Amplifier Gate is produced which will define the burst width, when combined within the gated amplifier. The burst width is defined by the user either directly, or as a function of the number of cycles and the burst frequency.
- The third output for each channel is an Amplifier Pre/Post Gate. The Pre/Post Gate is used to turn the amplifier on and off, hence the term gated amplifier. The Pre/Post Gate typically begins 1μsec before the Amplifier Gate, and ends 1μsec after the amplifier gate. The Pre/Post Gate is automatically generated as a function of the Amplifier Gate width and is not individually controlled by the user.

The burst outputs can be delayed in time with respect to the trigger. The burst outputs can be delayed individually, and swept individually swept as well through the use of software control. The burst delay can be controlled with a precision of 12.5 nanoseconds, allowing for precision beam mixing. Please note that due to the use of a Pre/Post Gate, there is a minimum burst delay of 1.65 microseconds.

Synthesizer Source	48-Bit Direct Digital Synthesizer (DDS)
Frequency Resolution	1 Hz Available (48-Bit Maximum)
Output Phase Resolution	0.022 Degrees (14 Bits)
DDS Output Level Control	0 - 100%
Burst Delay Range	1.65 microseconds to 6.55 milliseconds
Burst Delay Resolution	12.5 nanoseconds

Local Oscillator

In systems configured with a Superheterodyne Receiver, the third synthesizer channel is dedicated as the Local Oscillator (LO). The LO operates coherently with the burst output, and at a frequency 20 MHz above the designated frequency of analysis.

Timing Functions

The Synthesizer provides timing functions for the RAM-5000. In RAM-5000 systems without a Superheterodyne Receiver, the System Clock is also generated within the Synthesizer. In systems configured with a Superheterodyne Receiver, the System Clock is located within the Phase Detector Module.

In systems configured with a Superheterodyne Receiver, the timing functions also include the generation of the Integrator Gate.

Specifications of the Timing Functions are as follows:

Trigger Source	Internal, External, Computer
Maximum Internal Trigger Rate	10 KHz
Range	0.1 Hz to 10 KHz
External Trigger Input Requirement	+TTL
Trigger Output	+5V
Trigger Output Coherency	Start of RF Burst
Integrator Gate Width Range	0.1125 - 6550 microseconds in 12.5-nanosecond steps
Integrator Gate Delay	1.1125 - 6550 microseconds in 12.5-nanosecond steps
Integrator Gate Monitor Output	+TTL
Delays for Gated Amplifiers	1.65 - 6550 microseconds in 12.5-nanosecond steps

1.3 Gated Amplifier

Each Pulse Source in the RAM-5000 is equipped with a high-power Gated RF Amplifier. These Gated RF Amplifiers (currently the RM-145 Gated RF Amplifier) are capable of amplifying gated RF inputs of 1Vp-p to output levels as in excess of 5 KW RMS into 50 Ohms (1440 Vp-p).

Introduction to Gated Amplifiers

The operating principles of a Gated RF Amplifier are relatively simple. Unlike conventional CW amplifiers which are “on” and operating continuously, a Gated RF Amplifier is only on and operational for short durations of time, determined by the presence of a Gate Signal. When a Gate Signal is present, the amplifier is powered on and operational. When the Gate Signal is not present, the amplifier is off and not operational. This technique provides some very significant advantages in ultrasonic applications, specifically in size and economy, which we will discuss below.

Traditional ultrasonic applications involve the transmission of a pulse of limited duration. The duration, or width of the pulse, can range from a single high frequency spike, measured in nanoseconds, up to a many cycles of RF which can be measured in milliseconds. These pulses are typically repeated at a certain repetition rate. It's important to note that a transmitted signal will only be present for some small percentage of time during a test. We refer to this percentage as Duty Cycle.

The simplest definition of Duty Cycle is the amount of time in which the amplifier is operational, in relation to the amount of time in which the amplifier is off. When considering ultrasonic or repetitive burst applications, duty cycle can be simply defined by the function $DC = \text{Burst Width} \times \text{Repetition Rate}$. For example, if we consider a burst of 10 cycles at 1 MHz, the resulting Burst Width would be 10 microseconds. If we then consider a repetition rate of 100 Hz, the resulting duty cycle would be 0.1%.

By using a limited duty cycle within the amplifier, the Burst Power can be quite high, while keeping the Average Power of the amplifier is quite low. For example, if we consider a 1 KW burst at 0.1% duty cycle, the Average Power is only 1 Watt (not accounting for efficiencies and system losses). This allows the Gated Amplifiers to be designed and constructed smaller and more economically when compared to a CW amplifier

Power Ratings

When we discuss power, it is important to note exactly how we calculate power. Ritec amplifiers are rated in terms of RMS burst power into 50 Ohms. **Ritec amplifiers are not rated in terms of Peak Burst Power.** RMS Power is defined as the function

$$P_{RMS} = \frac{(0.707V_{Peak})^2}{R}$$

. If we consider a typical 5 KW Gated RF Amplifier, that power level equates to approximately 1440Vp-p into 50 Ohms. By comparison, many other manufacturers rate their amplifiers in terms of Peak Burst Power, which would be defined by

$$P_{Peak} = \frac{(V_{Peak})^2}{R}$$

the function . By this convention, Ritec's 5 KW RMS amplifiers produce greater than 10 KW Peak Power.

Ritec Gated RF Amplifier Signal Requirements

To operate, the Gated RF Amplifier requires three coherent signals. These signals are typically supplied by the internal Synthesizer, however upon request the RAM-5000 can be modified by Ritec to accept external signal inputs from an external signal generator. The three required signals are as follows:

1. **RF Signal Source:** An RF signal is required; this signal will be amplified and output from the Gated RF Amplifier en route to the transducer/probe. This signal is typically an RF Burst with a width equal to that of the desired output. A signal supplied as an RF Burst of greater width than the pulse, or effectively CW, will be shortened to the desired burst width through the gating process.
2. **Amplifier Gate:** The Amplifier Gate actually gates the RF signal, determining which portion of the RF signal will be amplified. The width of the amplifier gate is equal to the burst width.

3. **Amplifier Pre/Post Gate:** In the Ritec RM-145 Gated RF Amplifier, the Amplifier Pre/Post Gate acts as the gate which switches the amplifier on and off. The Pre/Post gate typically begins ~1 microsecond before the start of the burst (Pre-Gate), and ends ~1 microsecond after the end of the burst (Post-Gate). By switching the amplifier on and off outside of the burst, we isolate any switching artifacts from the burst.

Output Level Control

Output Level Control within the Gated RF Amplifier is determined through the adjustment of two parameters, RF Level Control and a DC Bias. Using the standard Output Level Control within the user interface, the output level is controlled on an arbitrary scale of 0 - 100. The standard Output Level Control automatically adjusts the RF Level Control and the Bias through a pre-defined algorithm. This algorithm has been programmed to offer performance over a broad range of frequencies and output conditions. The RF Level Control and the Bias can be manually adjusted to optimize the output signal for a given set of conditions.

Specifications

Input Level	1Vp-p (maximum) into 50 Ohms
Maximum Output Power	1.5 KW RMS (standard) 5 KW RMS (available)
Output Monitor Level	-60dB
Optimum Frequency Range	250 KHz to 7 MHz (standard) 50 KHz to 500 KHz (optional) <i>(modified frequency ranges are available upon request)</i>
Operational Frequency Range	200 KHz to 20 (30 in SNAP) MHz (standard) 40 KHz to 20 MHz (optional)
Maximum Duty Cycle	0.3%
Maximum Pulse Width	200 microseconds
Pulse Width Control	12.5-nanosecond steps
On/Off Ratio	>140dB
Output Level Control	>20dB

1.4 Broadband Receiver

A Broadband Receiver is standard in the RAM-5000 Mark IV and the 3C, which has 3 individual Broadband Receivers. This broadband receiver also serves as a component of the

optional Superheterodyne Receiver (standard in the RAM-5000 Mark VI and SNAP). This is a single channel receiver with two multiplexed inputs and a single RF output.

Receiver Inputs	2 (multiplexed)
Receiver Gain	78 dB (Maximum)
Operational Frequency Range	20 KHz to 20 (80 in SNAP) MHz
Receiver Gain Control	0 – 78 dB (22 - 100 in Mark VI and SNAP) in 2-dB steps
Receiver High Pass Filters	0.05/0.25 (0.1 in SNAP), 1 and 4 MHz
Receiver Low Pass Filters	5, 10 and 20 MHz (20, 40 and 80 MHz in SNAP)
Receiver Input Impedance	50 Ohms
Receiver Output Impedance	50 Ohms
Receiver Output Level	1 Vp-p (Linear Range)

1.5 Connectors and Monitors

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 [1-8](#)
- Rear Panel BNCs [1-10](#)

1.5.1 Front Panel Connectors

This section describes the instrument connectors that are located on the front panel of the RAM-5000-M4-Plus.

- RF BURST HIGH POWER OUT [1-9](#)
- RF BURST MONITOR [1-9](#)
- RECEIVER INPUT NO.1 [1-9](#)
- RECEIVER INPUT NO.2 [1-9](#)
- RECEIVER OUTPUT [1-10](#)

1.5.1.1 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.

1.5.1.2 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  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.

1.5.1.3 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.

1.5.1.4 RECEIVER INPUT NO.2

Impedance: 50 Ohm

Receiver input channel No.2.

Otherwise, same as for RECEIVER INPUT NO.1 [1-9](#).

1.5.1.5 RECEIVER OUTPUT

Impedance: 50 Ohm

Output for the receiver.

The maximum voltage of the output signal should not exceed 1 V peak-to-peak.

Note: The level of amplification at the RECEIVER OUTPUT with respect to the signal fed into one of the RECEIVER INPUT [1-9](#) channels is about 12 dB less than the total receiver gain specified by the Gain [4-4](#) control.

1.5.2 Rear Panel Connectors

This section describes the instrument connectors that are located on the rear panel of the RAM-5000-M4-Plus.

- SIGNAL OUT 1 [1-10](#)
- SIGNAL OUT 2 [1-10](#)
- SIGNAL OUT 3 [1-10](#)
- SIGNAL OUT 4 [1-10](#)
- GA PRE-GATE MON [1-14](#)
- TRIGGER IN [1-14](#)
- TRIGGER OUT [1-14](#)

1.5.2.1 SIGNAL OUT 1, 2, 3, 4

Impedance: 50 Ohms

There are multiple signals that can be monitored in a RAM-5000-M4-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-M4-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 [1-12](#) independently to monitor any of the following signals (actual availability depends on RAM-5000 system configuration)

- **Trigger**

Same as dedicated BNC TRIGGER OUT [1-14](#).

- **Synthesizer**

Monitors the gated RF Burst signal at the low-level stage before entering the respective Gated Amplifier for high-power amplification.

- **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 [1-9](#) 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 [1-9](#) on the front panel of the instrument, if your RAM-5000-M4-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 [1-9](#) channels is about 12 dB less than the total receiver gain specified by the Gain [4-4](#) control.

- **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.

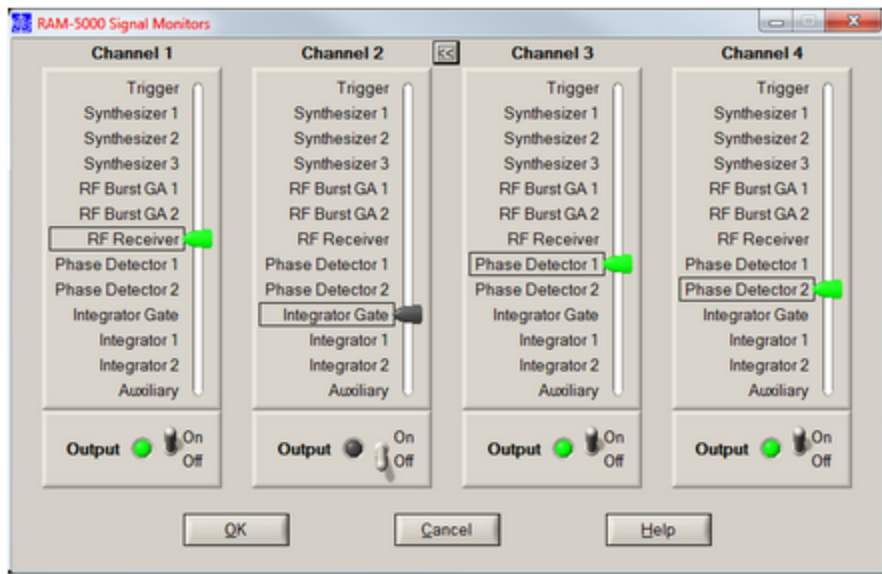
RAM-5000 Signal Output channels default configuration

The factory default configuration of the 4 signal outputs is as follows:

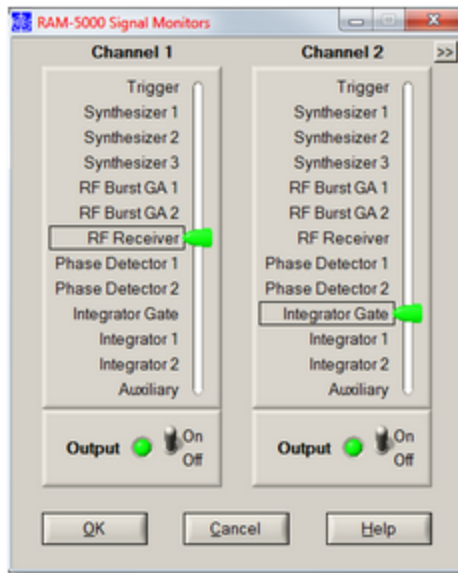
- Signal Out 1 = RF Burst 1 monitor at -60dB
- Signal Out 2 = **RF Receiver** output monitor
- Signal Out 3 = same as Signal Out 1
- Signal Out 4 = same as Signal Out 1

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 ²⁻⁵.



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 **Channel 1** 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.

1.5.2.2 GA PRE-GATE MON

Impedance: 150 Ohms

Monitors the signal that turns on the high-power Gated Amplifier No.1. This signal starts before and ends after the actual RF burst. Because the "pre-gate" time is set to one microsecond, the pre-gate monitor should not show any jitter with respect to the coherent TRIGGER OUT ¹⁻¹⁴.

This output signal is typically used as an input gate for the Clamped Diplexer RCDX-2A.

1.5.2.3 TRIGGER OUT

Impedance: 50 Ohms

Positive (5 V) trigger that is coherent with the RF tone burst from the gated amplifier.

1.5.2.4 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 ¹⁻¹⁴ connector.

Section 2

User Interface

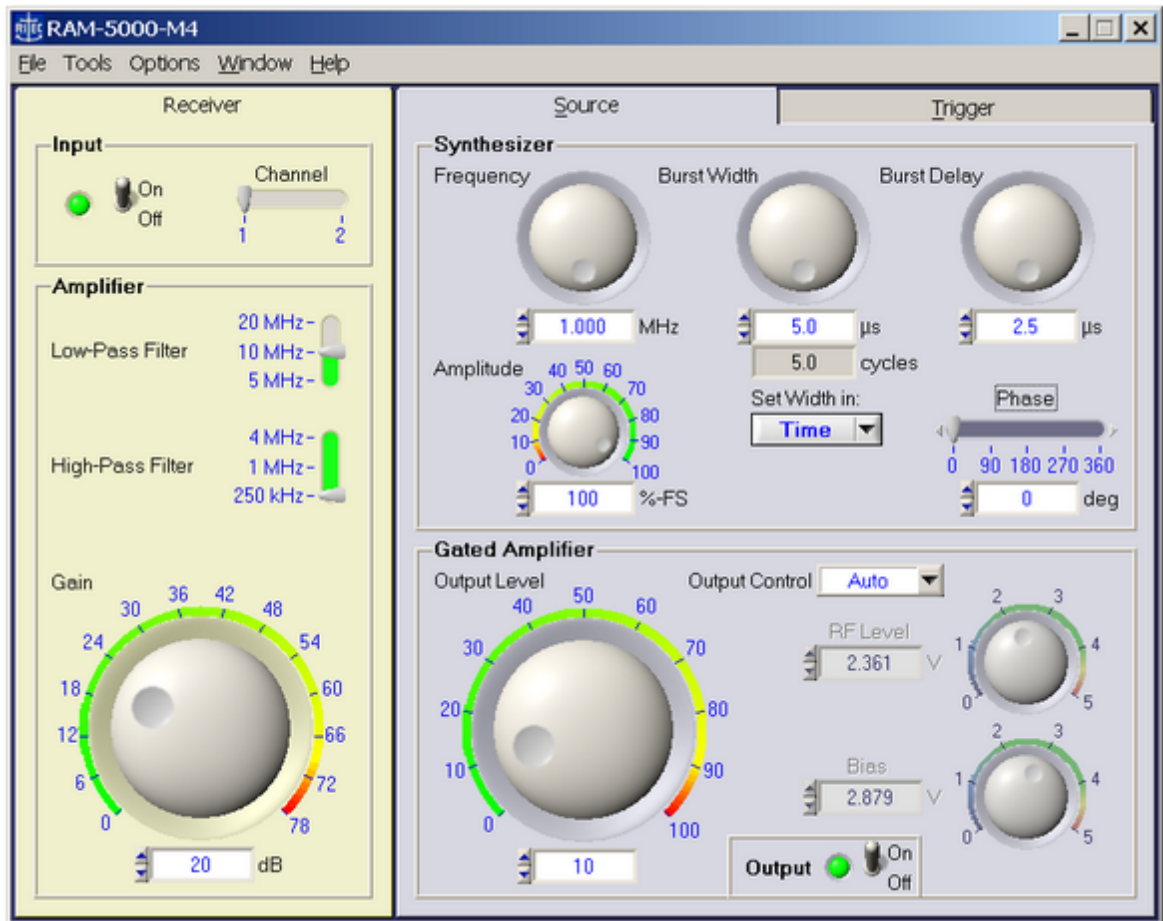
2 User Interface

This chapter provides an overview and describes general features of the software user interface to control the RAM-5000-M4-Plus instrument.

- Overview [\[2-2 \]](#)
- Main Menu [\[2-3 \]](#)
- Setting Preferences [\[2-8 \]](#)
- Controlling Instrument Parameters [\[2-12 \]](#)

2.1 Overview

The RAM-5000-M4-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-M4-Plus user interface provides full control over all instrument operation parameters.



The RAM-5000-M4-Plus User Interface in its default layout.

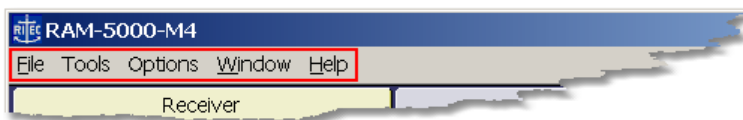
The layout of the instrument controls was designed to be similar to that of a typical instrument's hardware front panel. The controls are organized according to the instrument configuration and analog signal processing flow, and the locations of the actual instrument front panel connectors. Thus, the RAM-5000-M4-Plus user interface exhibits a right-to-left, top-down control and signal flow. The User Interface consists of two horizontally arranged main sections, one primarily comprising everything controlling signal generation, and a second comprising all controls for the various receivers.

On the right side of the User Interface main panel, there are two tabs, one with controls for the Pulse Source [3-2](#) and one for setting up the Trigger [5-2](#), as well as for controlling various other instrument options such as data acquisition using the Auxiliary A/D Channels [5-6](#). On the left side, there is a panel with controls for the Receiver [4-2](#).

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 'T' for Trigger.

The RAM-5000-M4-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-M4-Plus user interface main window, simply close it. Whatever customization you may prefer, it is all saved and fully restored between sessions.

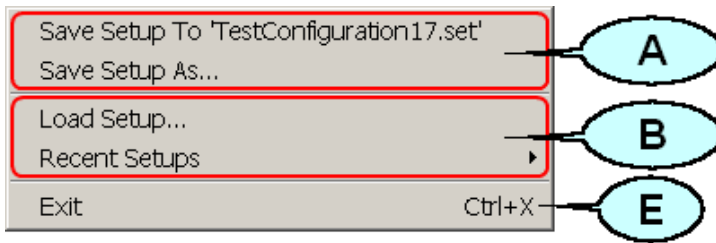
2.2 Main Menu



The main menu, located at the top of the RAM-5000-M4-Plus user interface, provides access to a series of named submenus. Each of these submenus are described individually:

- File [2-4](#)
- Tools [2-5](#)
- Options [2-6](#)
- Window [2-6](#)
- Help [2-7](#)

2.2.1 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 *'TestConfiguration17.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-M4-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.

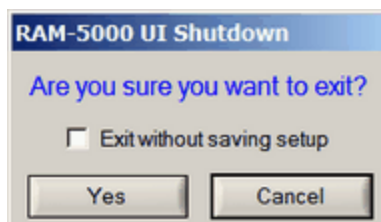
Save Setup As... opens a file/folder browser to save the current instrument setup to a specific folder and possibly under a new name.

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.

Shutting down the RAM-5000-M4-Plus User Interface (E)

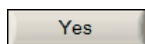


Exit, opens a confirmation prompt with the following options:

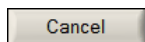
Exit without saving setup

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-M4-Plus User Interface to reuse the settings that were last saved when exiting normally.



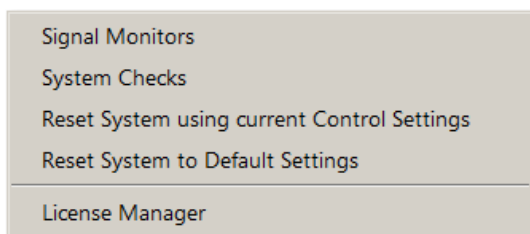
...proceed shutting down the User Interface. If the option "Exit without saving setup" was left in the unselected (default) state, the RAM-5000-M4-Plus User Interface automatically saves the current instrument setup and user interface settings before exiting.



...abort shutting down the User Interface.

Note: You can disable the confirmation prompt on the User Interface Preferences [\[2-9 \]](#) dialog panel.

2.2.2 Tools Menu



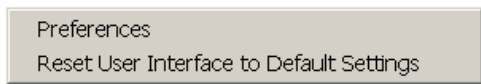
This menu provides access to various tools including the Signal Monitors configuration dialog [\[1-12 \]](#) and a number of System Checks [\[8-2 \]](#) that may be executed to verify that the RAM-5000-M4-Plus is working properly.

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-M4-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 [\[2-8 \]](#) settings are not affected by this reset (see Options Menu [\[2-6 \]](#) for resetting the User Interface).

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.

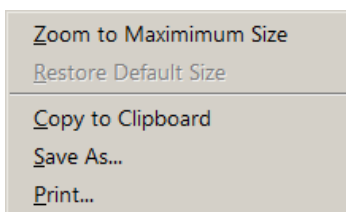
2.2.3 Options Menu



This menu includes a number of software configuration options. The item **Preferences** ²⁻⁸ 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-M4-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 ²⁻⁵ for resetting only the instrument).

2.2.4 Window Menu



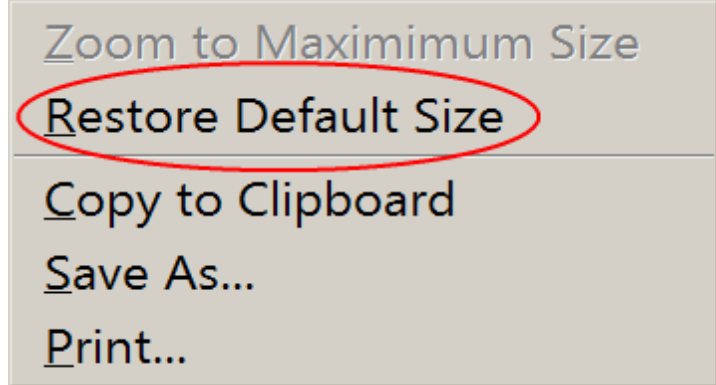
This menu contains items that control the size of the RAM-5000-M4-Plus user interface display. In addition, the Window Menu provides various options that allow you to create a bitmap image of the present display of the main window.

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 ²⁻³ 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^[2-6]). 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.

2.2.5 Help Menu



The Help Menu provides access to various types of information related to the RAM-5000-M4-Plus hardware and the installed software components.

Context opens the RAM-5000-M4-Plus Help viewer with help specific to the control or panel that was last activated or selected.


Contents opens the RAM-5000-M4-Plus Help viewer with the Table of Contents (TOC) visible, the TOC tree collapsed, and shows the introductory help topic.

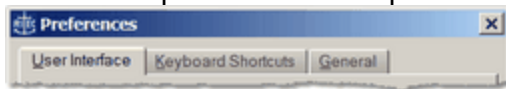
Index opens the RAM-5000-M4-Plus Help viewer with the Index visible, and shows the introductory help topic.


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.

2.3 Setting Preferences




In the RAM-5000-M4-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.

2.3.1 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-M4-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 Receiver panel. This option may be used, whether the main window is zoomed to maximum size^[2-6] 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-M4-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

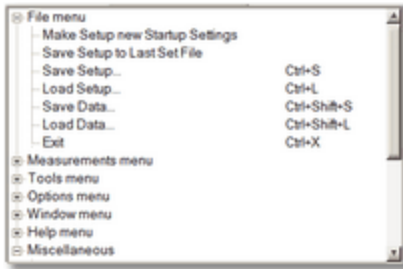
Enabling this option makes each freely moving window that belongs to the RAM-5000-M4-Plus User Interface sensitive to mouse pointer movements. Each window that the mouse pointer moves over (hovers) will be immediately brought into the foreground and activated for user input. This includes detached tabs and any add-on module user interface windows.

Prompt for confirmation on exit

If this option is enabled (the default setting), the RAM-5000-M4-Plus User Interface will display a confirmation prompt before shutting down the instrument user interface^[2-4]. 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.

2.3.1.1 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-M4-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-M4-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.

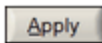
- o **Find** - Searches through the shortcuts list for a specified string of text.
- o **Expand All** - Shows all Menu and Miscellaneous subitems in the shortcuts list.
- o **Collapse All** - Hides all Menu and Miscellaneous subitems in the shortcuts list.



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




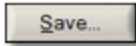
Key lists all the keys that are available for you to create shortcut key assignments with or without a **Modifier** key. Depending on the selected **Modifier**, you can select function keys, letter keys, various special keys, and for certain miscellaneous control actions also numeric keys.



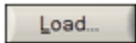
Click the **Apply** button to assign the currently selected **Modifier** and **Key** combination as the shortcut for the highlighted menu or control command.

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.

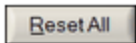
As a visual aid, the text label of the Apply button turns red  if the currently selected **Modifier** and **Key** combination is already in use.




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  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-M4-Plus User Interface or manually . This option is available only if the loaded data differs from the data in the shortcuts list .
- **Default** restores the default assignments. This option is available only if the default assignments differs from the assignments presently shown in the shortcuts list .

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.

2.3.2 General Preferences

Save standard deviation data

Enabling this option, the RAM-5000-M4-Plus User Interface calculates the standard deviation and stores it along with the main data (auxiliary A/D channel no.1 and/or channel no.2 voltages) in a log data file, when using *Mean Averaging* ^[5-12].

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 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.

2.4 Controlling Instrument Parameters

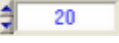

All instrument parameters can be controlled via *menu*, *numeric*, or *knob* user interface controls. A menu control ^[2-13] is used when the instrument parameter may be set to a limited number of specific options, such as filter settings. A numeric control ^[2-13] is used when the instrument parameter 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 ^[2-15] value. An editable numeric control may be complemented by a knob or slider control to allow for large changes in the parameter setting without the need to adjust the Step Size value or having to key in each value.

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

- Source Controls ^[3-2]
- Receiver Controls ^[4-2]


2.4.1 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.


2.4.2 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 shows a unit label, e.g. “MHz”, 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 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-M4-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-M4-Plus User Interface, based on control value keyboard input (see Smart Auto Step Sizing [2-15](#) for more information).

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

Many editable numeric controls also have an associated knob or slider control right next to or above it. These types of controls allow for a series of large changes in the parameter setting without the need to adjust the Step Size value or 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 and possibly color-coded range sections. 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 and color-coded range sections.

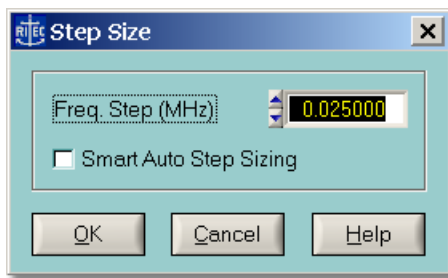


Both types of knobs as well as a slider may be operated using the mouse or the keyboard. To turn a knob using the mouse, simply move its pointer on any part of the center piece and then left-click and drag it clock-wise or counter-clock-wise. Using the mouse with a slider is similar to both operating 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 an instrument parameter 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), with one small exception. In the case of an activated/selected knob or slider control, the descriptive text label, e.g. "Frequency", will be surrounded by a dotted rectangle.

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 instrument parameter value.

2.4.3 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-M4-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 [2-15](#)
- Smart Auto-Sizing [2-15](#)

2.4.3.1 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.

2.4.3.2 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 3

Source Controls

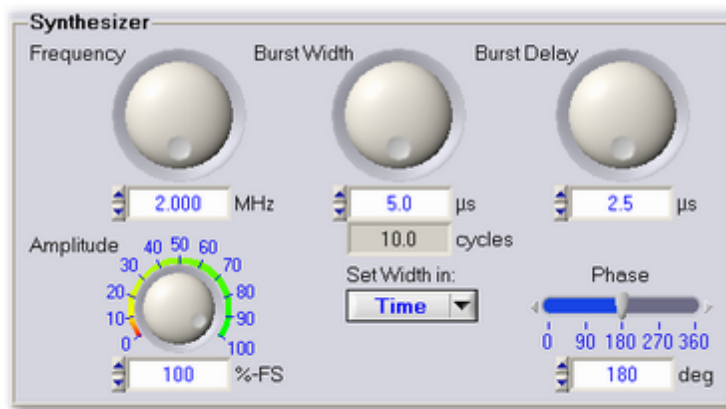
3 Source Controls

The RAM-5000-M4-Plus may contain up to two nominally identical Pulse Sources. The controls for each Source are described in the following two sections.

- Synthesizer [3-2](#) - Frequency, Burst Width and Delay, Phase, and Amplitude
- Gated Amplifier [3-5](#) - Output Control and Level, RF Level and Bias Controls, Output Enable

Note: Throughout the RAM-5000-M4-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.

3.1 Synthesizer



Synthesizer Controls

The Synthesizer of the RAM-5000-M4-Plus Pulse Source setup has the following control options:

- Frequency [3-3](#)
- Burst Width [3-3](#)
- Burst Delay [3-4](#)
- Phase [3-4](#)
- Amplitude [3-4](#)

3.1.1 Frequency

Nominal range: 0.2 to 20 MHz in 1-Hz steps. For the range of your RAM-5000-M4-Plus refer to the **Specifications** in the Appendices [9-2](#).

This control [2-13](#) 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 [3-4](#).

3.1.2 Burst Width

Nominal range: 0.1125 to 200 μ s in 12.5-ns steps, or 1 RF cycle up to the equivalent of a 200 μ s burst width in 1-cycle steps. For the range of your RAM-5000-M4-Plus refer to the **Specifications** in the Appendices [9-2](#).

This control [2-13](#) is for setting the burst width. Depending on the set Burst Width Mode [3-4](#), 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 [3-3](#).

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 [3-3](#).

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.

3.1.2.1 Width Mode

Setting this control $\overline{2-13}$ determines whether the Burst Width $\overline{3-3}$ 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 Width in:" is set to **Cycles** () 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 Width in:" is set to **Time** () 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.

3.1.3 Burst Delay

Nominal range: 1.6125 to 6550 μ s in 12.5-ns steps. For the range of your RAM-5000-M4-Plus refer to the **Specifications** in the Appendices $\overline{9-2}$.

This control $\overline{2-13}$ is for setting the delay between the trigger and the start of the amplifier gate that creates the high-power pulse.

3.1.4 Phase

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

This control $\overline{2-13}$ is for setting the start phase of the toneburst.

3.1.5 Amplitude

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

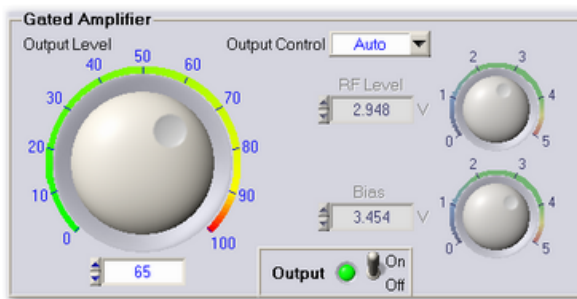
This control $\overline{2-13}$ is for setting the output amplitude level of the synthesizer.

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

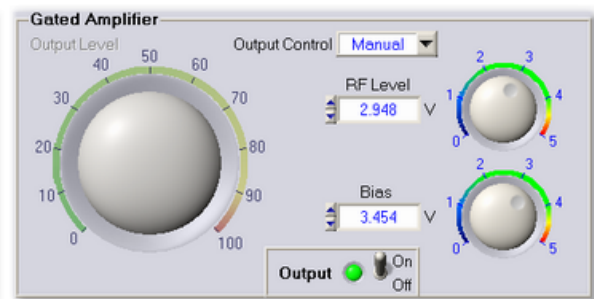
determined by the present gated amplifier settings. Due to hardware limitations, the possible level values cover a wide range of "odd" numbers, as they are purposefully not rounded to a lower precision.

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.

3.2 Gated Amplifier



Gated Amplifier controls in Automatic Output Control mode.



Gated Amplifier controls in Manual Output Control mode.

The Gated Amplifier of the RAM-5000-M4-Plus Pulse Source setup has the following control options:

- Output Control [3-5](#)
- Output Level [3-6](#)
- RF Level Control [3-7](#)
- Bias Control [3-7](#)
- Output Enable [3-8](#)

3.2.1 Output Control

Standard settings: Manual, Auto, and Auto-Fine

This control [2-13](#) is for setting the gated amplifier output control mode.

The gated amplifier output level is controlled by the RF Level Control [3-7](#) and the Bias Control [3-7](#) 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-M4-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 $\overline{3-6}$ 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 $\overline{3-6}$ 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.

3.2.2 Output Level

Nominal range: 0 to 100

This control $\overline{2-13}$ is for setting the high-power output level of the respective gated amplifier using the default output algorithm.

If the Output Control $\overline{3-5}$ 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 $\overline{9-2}$). 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-M4-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 $\overline{2-13}$ voltage when in manual output control mode.

3.2.3 RF Level Control

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

This control $\overline{2-13}$ 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-M4-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 $\overline{3-5}$ mode is not set to **Manual**.

If the receiver is saturated by the strength of the received signal even at 0 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.*

3.2.4 Bias Control

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

This control $\overline{2-13}$ 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-M4-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-M4-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 [3-5](#) 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).

3.2.5 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-M4-Plus hardware front panel using the toggle switch, labeled HIGH VOLTAGE, which is located below the red LED.

Section 4

Receiver Controls

4 Receiver Controls

The RAM-5000-M4-Plus may contain up to two nominally identical dual-channel-input broadband Receivers. The controls for each Receiver are described in this chapter, which is divided into two sections.

- Input [4-2](#)
- Amplifier [4-3](#)

4.1 Receiver Input



Receiver Input Controls

The Input controls of each RAM-5000-M4-Plus Receiver setup comprise the following options:

- Input Enable [4-2](#)
- Input Channel [4-2](#)

4.1.1 Input Enable

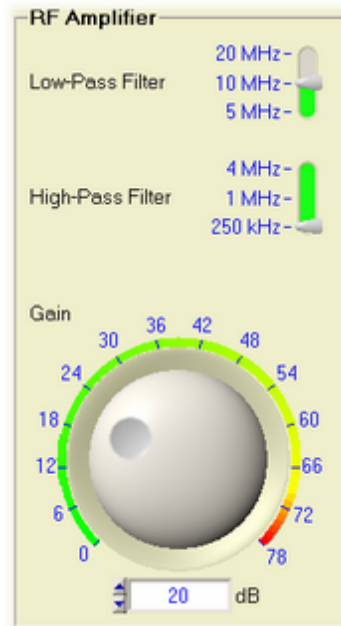
This toggle switch is for quickly disabling or enabling the input to the Receiver. This function is useful when performing oscilloscope or internal background signal diagnostics.

4.1.2 Input Channel

Standard options: Channel 1, and Channel 2. For the number of channels in your RAM-5000-M4-Plus refer to the **Specifications** in the Appendices [9-2](#).

This control [2-13](#) is for setting the active Receiver Input Channel.

4.2 Receiver Amplifier



Receiver Amplifier Controls

The Amplifier controls of the RAM-5000-M4-Plus Receiver setup comprise the following options:

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

4.2.1 Low-Pass Filter


*Standard settings: 5, 10, or 20 MHz. For the settings of your RAM-5000-M4-Plus refer to the **Specifications** in the Appendices [9-2](#).*

This control [2-13](#) 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.

4.2.2 High-Pass Filter

*Standard settings: 0.25, 1, or 4 MHz. For the settings of your RAM-5000-M4-Plus refer to the **Specifications** in the Appendices [9-2](#).*

This control  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.

4.2.3 Gain

Standard range: 0 to 78 dB in 2-dB steps

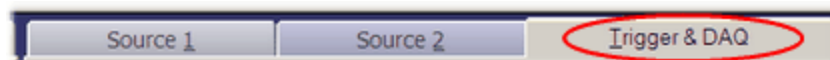
This control  is for setting the RF signal gain in the Receiver Amplifier module.

Section 5

Triggering & DAQ

5 Triggering & DAQ

This chapter describes the various controls located on the RAM-5000-M4-Plus User Interface's *Trigger & DAQ* tab.

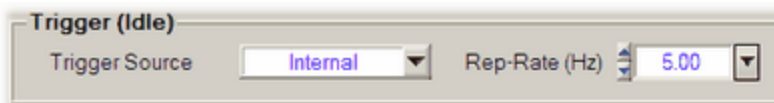


The Trigger & DAQ Tab

The controls on the Trigger & DAQ tab are used primarily to set up and control triggering and optional data acquisition. In addition, if the RAM-5000-M4-Plus system is equipped with multiple gated amplifiers, one other control on this tab may be used to control, from a central location on the user interface, which of the Gated Amplifier Outputs is active (enabled).

- General-Purpose Triggering [5-2](#)
- Active GA Outputs [5-5](#)
- Data Acquisition and Automation [5-6](#)
- Data Acquisition Triggering [5-12](#)

5.1 Trigger



Idle Trigger sub 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. To set, for example, the burst rep-rate that would be applicable during a measurement, use the trigger controls located on the Data Acquisition [5-6](#) panel.

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 [5-3](#)
- Manual Trigger [5-3](#)
- Burst Rep-Rate [5-4](#)
- External Trigger [5-4](#)

5.1.1 Trigger Source


Standard settings: Manual, Computer, Internal, or External

This control  is for setting the source of the *idle* trigger.





Setting the trigger source to **Manual**  enables a push button next to 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  next to 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  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-M4-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 " of the RAM-5000-M4-Plus will remain coherent with both the RF and the burst.

5.1.2 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.

5.1.3 Burst Rep-Rate

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

This control [2-13](#) is for setting the idle (as opposed to data acquisition) burst rep-rate when the Trigger Source [5-3](#) 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-M4-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 [5-3](#) control is set to any setting other than *Manual*, the rep-rate parameter needs to be chosen in conjunction with the Burst Width [3-3](#) and the gated amplifier Output Level [3-6](#) to insure a clear waveform presentation on the oscilloscope without exceeding the duty-cycle limitation of the RAM-5000-M4-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.

5.1.4 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-M4-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 [\[5-4 \]](#) control.

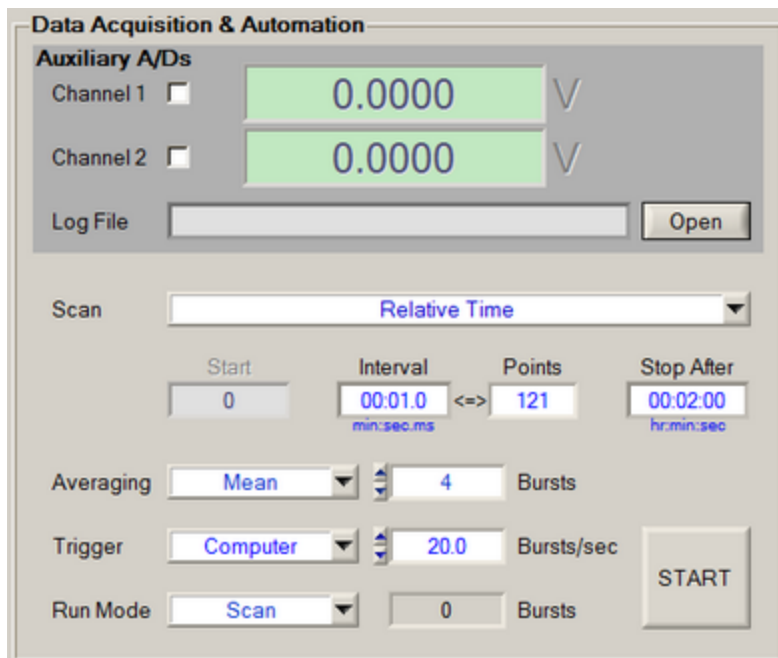
The external trigger rep-rate monitor also includes a green LED, located immediately next to the rate readout. The LED provides an additional visual indication of the external trigger rate and status. Thus, the color of the LED is reset to *green* with each newly registered external trigger event and 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 [\[1-9 \]](#) on the RAM-5000-M4-Plus front panel is not activated).

5.2 Active GA Outputs



This control [\[2-13 \]](#) is useful for setting the active pulse source(s) using a single auxiliary control, in a RAM-5000-M4-Plus system with multiple Gated Amplifiers. It is linked to the Output Enable [\[3-8 \]](#) toggle switch for each pulse source.

5.3 Data Acquisition and Automation



The Data Acquisition & Automation sub panel.

The RAM-5000-M4-Plus features two auxiliary A/D channels for acquiring data from external measurement devices, that output a DC voltage signal. 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.

The RAM-5000-M4-Plus User Interface allows you to collect such data, in parallel with your oscilloscope-based data acquisition, using various acquisition trigger options.

- Auxiliary A/D and Data Logging [5-6](#)
- Automation [5-8](#)
- Averaging [5-12](#)
- Triggering [5-12](#)
- Run Modes [5-15](#)

5.3.1 Auxiliary A/D Channels

This group of controls and meters is for enabling and monitoring data acquisition via the available Auxiliary A/D input channels.

Two Auxiliary A/D channels, labeled "External Sensor" on the rear panel of the RAM-5000-M4-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.

- Channel Reading and Data Display [5-7](#)
- Data Logging [5-7](#)

5.3.1.1 Channel Reading & Data Display

To enable acquisition on either A/D channel, check mark the appropriate box labeled "Channel 1" or "Channel 2". Once enabled, the data display to the right is updated in response to a trigger signal (when Averaging [5-12](#) is set to OFF) and will show the voltage reading for the respective channel. When using Averaging, the voltage display for the respective channel is updated at the end of a data acquisition cycle.

Note: Please note that it requires a separate trigger event to read each channel.

5.3.1.2 Data Logging

In either of the two acquisition Run Modes [5-15](#), interactively acquired data can be stored in a log file [5-7](#). 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.

Log File Format

A RAM-5000-M4-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.

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 Run Mode [5-15](#) for more information on what comprises a data acquisition cycle).

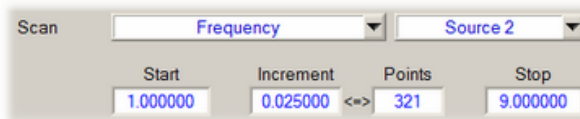
Dependent upon the active acquisition Run Mode, the time stamp data is formatted in one of two ways:

In Run Mode *Single*, 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.

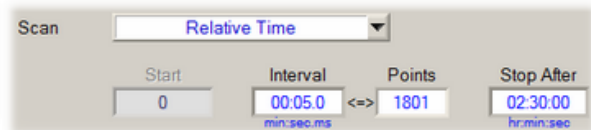
In Run Mode *Continuous*, the time stamp is formatted as *Seconds.Milliseconds* and represents the time relative to when data acquisition was started. Thus, the first logged measurement point will have the relative time stamp data of "0.0". Its absolute time stamp data is stored as part of the column 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.

5.3.2 Automation



Example of a Frequency Source 2 scan setup.



Example of a Relative Time scan setup.

The group of controls labeled *Scan* contains controls related to automated data acquisition. Using these controls, 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.

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

- **Scan Type** ⁵⁻⁸ | **Source** ⁵⁻¹⁰
- **Range Parameters** ⁵⁻¹⁰ - *Start, Increment, Points, Stop*

5.3.2.1 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-M4-Plus configuration.

The standard scan type allows for scanning the **Frequency** of a particular source ³⁻³, if applicable. The scan type **Relative Time** allows for performing timed data acquisition, that is, for acquiring data from the auxiliary A/Ds, or waveforms if combined with a digitizer, as a function of time.

If your RAM-5000-M4-Plus configuration includes either the PLUS option or the Oscilloscope add-on, you will also have the scan type **External Trigger Events** for acquiring data as a function of the external trigger signal timing.

Additional details on each particular Scan Type are described below:

- Relative Time [5-9](#)
- External Trigger Events [5-9](#)

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-M4-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 [5-14](#) setting, the second trigger increment is determined by your scan increment [5-10](#) 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 acquire some data with an Averaging setting of 4 Bursts, 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.

In an **External Trigger Events** scan, the dependent variable is not a RAM-5000-M4-Plus instrument parameter of operation, such as the burst frequency. Instead, the dependent variable in an External Trigger Events scan may be, for example, the position of a mechanical scanner or the setting of a materials testing device. That means, the event that triggers a complete data acquisition cycle at each scan point would be a certain voltage change at the TRIGGER IN [1-14](#) connector. This type of scan requires a TTL signal and allows for externally timed, automated data acquisition.

The scan range and increment are specified, as for pre-defined scan types, using the Range Parameter [5-10](#) controls. In the case of an External Trigger Events scan, however, the range parameters define an empirical scan range, based on a measurement setup controlled elsewhere, and the resolution is always 1 and cannot be changed. That is, the *Start* and *Stop* values are primarily used for defining the empirical range, while the number of *Points* value

determines after how many completed acquisition cycles the scan run in the RAM-5000-M4-Plus User Interface is supposed to end.

When selecting the scan type External Trigger Events, the actual data acquisition burst trigger source [5-13](#) is automatically set to *Computer*.

When an External Trigger Events scan is initiated, the Idle Trigger [5-2](#) controls will change to the *run-time* Scan Point Trigger controls for the duration of the scan. That is, a trigger rate monitoring display will be available that operates similar to the external burst rep-rate monitor [5-4](#) for the Idle Trigger.

Note: The burst rep-rate [5-14](#) setting controls the timing while a data acquisition cycle executes. During that time, the RAM-5000-M4-Plus instrument hardware will not be capable of sensing an external trigger. That means, 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 events 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.

5.3.2.2 Source

This control is used for selecting one of the available sources, if applicable, in conjunction with a particular Scan Type [5-8](#). For example, when the scan type *Frequency* is selected, and the present RAM-5000-M4-Plus configuration includes more than one source synthesizer, you can use this control to choose which of those to scan.

The scan types *Relative Time* and *External Trigger Event* do not involve a source selection, in which case this control will not be available.

5.3.2.3 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 . 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.

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.

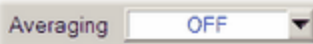
The Data Table and the Scan Graph will show structured time values up to 72 hours as *Hours:Minutes:Seconds* and time values longer than 72 hours as *Days:Hours:Minutes:Seconds*.

5.3.2.4 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. Additional columns could comprise the respective standard deviation data [2-12](#).

5.3.3 Averaging



The Averaging control when averaging is disabled.



The Averaging control when averaging is enabled.

The RAM-5000-M4-Plus User Interface offers *Mean* Averaging to average auxiliary A/D channel data readings. When averaging is enabled, the number of *Bursts* control value determines the amount of averaging. Averaging is optional and may also be disabled by choosing the *Averaging* control setting *OFF*.

Tip: Use averaging in conjunction with Run Mode [5-15](#) *Single* as a means to automatically trigger a specific number of bursts at a certain rep-rate. The number of *Bursts* control value, times the number of enabled auxiliary A/D channels, determine the total number of bursts being triggered using the acquisition Trigger settings. However, you could use this capability even if you do not wish to acquire RAM-5000-M4-Plus auxiliary A/D channel data, because the acquisition Trigger and Run controls will be functional either way. If none of the auxiliary A/D channels is enabled, the number of *Bursts* control value becomes the count-down control value.

5.3.3.1 Mean Average

Mean averaging provides a good signal-to-noise ratio improvement capability. The data calculated and displayed is the arithmetic mean value of N_{AVE} successive auxiliary A/D channel 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 averaging count, N_{AVE} , can be set using the number of *Bursts* control next to the *Averaging* control, when the latter is set to *Mean*.

5.3.4 Triggering

The trigger setup comprises two controls, the Trigger Source [5-13](#) and the Burst Rep-Rate [5-14](#). 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 [5-15](#), 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 [5-2](#) should be used.

5.3.4.1 Trigger Source

This control [2-13](#) is for setting the source of the data acquisition burst trigger.

Setting the trigger source to **Computer** or **Internal** enables a rep-rate control [5-14](#) next to source control for selecting the desired trigger repetition rate.

Setting the trigger source to **External** enables a rep-rate monitor [5-15](#) 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-M4-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 [1-14](#)" of the RAM-5000-M4-Plus will remain coherent with both the RF and the burst.

If the data acquisition Run Mode [5-15](#) 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.

5.3.4.2 Burst Rep-Rate

This control $\left[\begin{smallmatrix} 2-13 \\ 5-13 \end{smallmatrix} \right]$ is for setting the data acquisition burst rep-rate when the Trigger Source $\left[\begin{smallmatrix} 2-13 \\ 5-13 \end{smallmatrix} \right]$ 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 signal averaging $\left[\begin{smallmatrix} 2-13 \\ 5-12 \end{smallmatrix} \right]$ is used, with an averaging count control value of 20, and both auxiliary A/D channels enabled, then it would require a rep-rate of 40 bursts per second to obtain final data values once every second. 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-M4-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-M4-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-M4-Plus instrument parameter of operation, such as burst frequency.

5.3.4.3 External Trigger

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

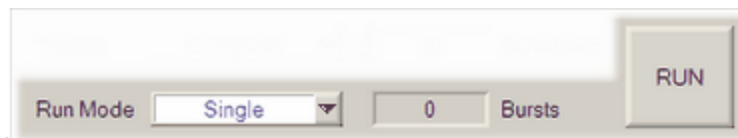
While externally generated trigger events can be registered up to rates as high as 1 kHz, the rep-rate monitor display will be updated at a maximum rate of only 5 Hz.

Note: At rates higher than 1 kHz, the rep-rate monitor will no longer work. However, the RAM-5000-M4-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 [\[5-4\]](#) 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-M4-Plus User Interface at a certain rep-rate before switching to External where the external rep-rate generator is running at the same rate.

5.3.5 Run Mode



Acquisition Run Controls

The Run Mode control determines the method of acquisition, that is, how complete data acquisition *cycles* are executed. In the RAM-5000-M4-Plus user interface, a data acquisition *cycle*, or measurement data point, may consist of numerous individual auxiliary A/D channel data read events, each requiring a separate trigger. For example, a single measurement point would comprise a total of 20 triggered bursts, when using Averaging [\[5-12\]](#) with the number of *Bursts* control value set to 10 and both auxiliary A/D channels being enabled.

Located next to the Run Mode control are the Burst Counter [\[5-16\]](#) and the acquisition RUN [\[5-16\]](#) button. The RAM-5000-M4-Plus User Interface provides two 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.

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 [5-8](#). However, you may cancel the scan at any time via the STOP button.

5.3.5.1 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 [5-15](#) is changed. 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 one auxiliary A/D channel (if enabled).

5.3.5.2 RUN/START/STOP

This button is the primary control for beginning and ending data acquisition in accordance with the selected Run Mode [5-15](#).



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.

Note: You also can use a keyboard shortcut [2-9](#) to start and stop acquisition. The default shortcut key assignment for this control is **F9**.

Section 6

Add-on Modules

6 Add-on Modules

6.1 Oscilloscope

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

- Overview [6-3](#)
- User Interface [6-4](#)
- General Setup [6-13](#)
- Vertical Controls [6-15](#)
- Horizontal Controls [6-18](#)
- Trigger [6-24](#)
- Acquisition [6-26](#)
- Spectrum Analyzer [6-34](#)
- Storing Data [6-38](#)
- Measurements [6-42](#)

Version 1.1.2 (May 2022)

6.1.1 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.







6.1.1.1 Integration into RAM-5000

The Oscilloscope user interface is highly integrated with the RAM-5000 user interface in many aspects. To list just a few:

- RAM-5000 setups maintain a link to the Oscilloscope user interface and automatically keep a separate record of it.
- Data acquired with the RAM-5000 user interface can be linked to waveforms and spectrum data.
- Viewing the RAM-5000 measurement Integrator Gate with respect to ultrasonic waveform data in time usually requires a dedicated acquisition channel when using a stand-alone benchtop oscilloscope to sample the Integrator Gate signal. Instead, the Oscilloscope user interface can display the Integrator Gate start and extend without sacrificing a costly digitization channel.
- But probably the most powerful feature is the ability to automatically have the Oscilloscope user interface acquire averaged and filtered waveforms fully synchronized with all of the various RAM-5000 data acquisition capabilities at high trigger rates, using the various Streaming capabilities.



6.1.2 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 

6.1.2.1 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.

6.1.2.2 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  6-7


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... [6-5], 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 [6-40] 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 [6-43] dialog for setting up various types of measurement cursors for each active graph.

Measure opens the Measurements [6-42] 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 [6-28] dialog with tabs for setting Sampling, Filtering, and Streaming options.

Display opens the Display Options [\[6-8\]](#) 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 [\[6-34\]](#) 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.

6.1.2.3 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 [\[6-17\]](#), 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 [\[6-22\]](#) controls.

Y axis scaling is controlled automatically when setting the Sensitivity [\[6-15\]](#) or the Full Scale [\[6-16\]](#).

6.1.2.4 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 [\[6-13\]](#), 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.

6.1.2.5 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 [6-15] panel (*Vertical* tab), on the Acquisition Controls [6-26] panel (*Acquisition* tab), on the Acquisition Options [6-26] panel's *Filtering* tab, and on the Display Options [6-8] 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.

6.1.2.6 Controlling the Oscilloscope


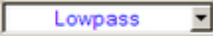
All Oscilloscope settings can be controlled from the Oscilloscope user interface via *menu*, *numeric*, or *knob* controls. A menu control  is used when the control may be set to a limited number of specific options, such as time-per-division settings. A numeric control  is used when the control may 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.

6.1.3 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 [6-13](#)
- Input Channels [6-13](#)
- RAM Gate Channel [6-13](#)

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](#) [6-18](#), [Vertical](#) [6-15](#), [Trigger](#) [6-24](#), and [Acquisition](#) [6-26](#).

6.1.3.1 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 [1-10](#) 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**.

6.1.3.2 Input Channels

Use the *Channel Selector* [6-9](#) 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.

6.1.3.3 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.

6.1.4 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 [6-9](#).

- Sensitivity [6-15](#)
- Variable Gain Mode [6-15](#)
- Full Scale [6-16](#)
- Grid Labels [6-16](#)
- DC Offset [6-17](#)
- Channel Equalization Mode [6-17](#)
- Input Coupling [6-17](#)

6.1.4.1 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 [6-17](#) is enabled, the Sensitivity level of all other channels is adjusted. If necessary, the DC Offset [6-17](#) and the Trigger Level [6-25](#) 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 [6-19](#) 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 [6-19](#) control, when using Variable Gain [6-15](#).

6.1.4.2 Variable Gain Mode

The checkbox control, labeled "Variable", located below the Sensitivity [6-15](#) / Full Scale [6-19](#) 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 [6-16](#) 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 [6-16](#) control.

6.1.4.3 Full Scale

This control sets the vertical range and determines the waveform graph Y axis view range, when working in the Variable Gain [6-19](#) 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 [6-17](#) is enabled, the Full Scale setting of all other channels is adjusted. If necessary, the DC Offset [6-17](#) and the Trigger Level [6-25](#) 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 [6-19](#).

Note: The Full Scale control is not available, and is replaced by the Sensitivity [6-19](#) control, if Variable Gain [6-15](#) is disabled.

6.1.4.4 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 [6-19](#) 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.

6.1.4.5 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 [6-17](#) is enabled, the DC Offsets settings of all channels are adjusted the same.

6.1.4.6 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 [6-26](#) and all of the Spectrum Analyzer [6-34](#) 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.

6.1.4.7 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.

6.1.5 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 [6-18](#)
- Variable Timebase Mode [6-19](#)
- Time Width [6-19](#)
- Grid Labels [6-20](#)
- Samples [6-20](#)
- Fixed Sampling Rate Mode [6-21](#)
- Sampling Rate [6-21](#)
- Zooming [6-22](#)

6.1.5.1 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 [6-22](#) is enabled (Magnify [6-22](#) 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 [6-21](#) 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 [6-19](#) 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 [6-19](#) control, while using the Variable Timebase [6-19](#) mode.

6.1.5.2 Variable Timebase Mode

The checkbox control, labeled "Variable", located below the Timebase [6-18](#) / Time Width [6-19](#) 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 [6-19](#) 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 [6-20](#) control.

6.1.5.3 Time Width

This control is for setting the acquisition timebase when in the Variable Timebase [6-19](#) 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 [6-22](#) is enabled (Magnify [6-22](#) 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 [6-21](#) 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 [6-19](#).

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 [6-18](#) control, if the Variable Timebase [6-19](#) mode is disabled.

6.1.5.4 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 [6-19](#) 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.

6.1.5.5 Samples

This control is labeled only in terms of the unit "S", and is located to the right of the Timebase [6-18](#) / Time Width [6-19](#) 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 [6-22](#) is enabled (Magnify [6-22](#) 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 [6-19](#) mode and then control the acquisition time in the Variable Timebase [6-19](#) mode.

To control the sampling rate and allow the number of samples to acquire to be adjusted automatically, switch to the Fixed Sampling Rate [6-19](#) 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 [6-19](#) control, when using the Fixed Sampling Rate [6-19](#) mode.

6.1.5.6 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 [6-20](#) control into the Sampling Rate [6-21](#) 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.

6.1.5.7 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 [6-18](#) Time Width [6-19](#) 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 [6-19](#) mode. You would then change the Samples [6-20](#) 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 [6-19](#) 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  control, if the Fixed Sampling Rate  mode is disabled.

6.1.5.8 Zooming

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

- Magnify 
- Position 

Magnify


This control is for enabling horizontal zooming and setting the zoom factor. If zooming is enabled, you can use the Position  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  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.

6.1.6 Trigger

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

- Trigger Delay 
- Trigger Source 
- Trigger Type 

6.1.6.1 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 ≥ 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.

6.1.6.2 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.

6.1.6.3 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 [6-24](#) 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.

6.1.7 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 [\[6-6\]](#) menu), which can be used to set additional sampling and filtering parameters, and to configure Streaming.

- Averaging [\[6-26\]](#)
- Filtering [\[6-27\]](#)
- Run Controls [\[6-28\]](#)
- More Options [\[6-28\]](#)
- Maximizing Acquisition Speed [\[6-32\]](#)

6.1.7.1 Averaging

You can use averaging to reduce the effects of noise. The type of averaging employed is *Continuous Averaging*. When you are Streaming [\[6-39\]](#), the Oscilloscope user interface automatically employs *Summed Averaging* [\[6-27\]](#). Averaging can be configured independently for each acquisition channel, unless Channel Equalization [\[6-17\]](#) 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.

6.1.7.2 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.

6.1.7.3 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.




Note: The run controls are not available for user input, and are dimmed, when the Idle Trigger Source  in the RAM-5000 user interface is set to *Manual* or *Computer*.

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.

6.1.7.4 More Options

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

•

- Sampling  6-29
- Filtering  6-30
- Streaming  6-31

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 [6-9](#)).

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 [6-26](#) 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 Cauer

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 Cauer (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 [\[6-5 \]](#) 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 [\[6-27 \]](#) instead of Continuous Averaging [\[6-26 \]](#), 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.

6.1.7.5 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 [6-8](#) 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 [6-27](#), in particular when acquiring long waveforms.
- Limit waveform acquisition to one channel.
- Reduce the number of Samples [6-20](#) per waveform, that is, either directly, by reducing the Sampling Rate [6-21](#), or by reducing the Timebase [6-18](#) when using a fixed sampling rate.
- Disable Measurements [6-42](#) and Cursors [6-43](#) with the "Snap to nearest data point" option enabled.
- Disable the Spectrum Analyzer [6-34](#), or limit to one channel, and/or do not use the Auto-scaling [6-35](#) 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 [6-40](#).
- Reduce the trigger repetition rate of your signal source, for example the RAM-5000.
- Hide (Minimize) the Oscilloscope user interface.

6.1.8 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 [6-40](#)) 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 [6-34](#)
- Spectrum Graph [6-36](#)

6.1.8.1 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 [6-18](#) setting and the active Sampling Rate [6-21](#). For example, when using the Fixed Sampling Rate [6-21](#) 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 [6-9](#) control to select the Spectrum Analyzer channel you want to enable and configure. When Channel Equalization [6-17](#) 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*.

6.1.8.2 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  6-34.

6.1.9 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 [6-57](#)).

At almost any time, you can save the currently displayed waveform(s) and associated spectral data [6-57](#) (if the Spectrum Analyzer [6-34](#) is active) to a file in one of several different file formats [6-38](#), for importing into a third-party software application.

In addition, you can use Streaming [6-39](#) 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.

6.1.9.1 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, which 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`.

```
TSsecsUTC=floor(TimeStampChn1);
TSfrac=rem(TimeStampChn1,1);

TSsecsLocal=TSsecsUTC-(3600*5);
dnTS1900=TSsecsLocal./86400;
dnTS=datenum(1900,1,1,0,0,0)+dnTS1900;

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

TSfracStr=num2str(TSfrac, '%.3f');
```

```

TSfracStr =
0.318
0.091
0.894
0.707
0.516

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

```

Choose the file extension **".tdms"** for saving the applicable data into a binary file conforming to the National Instruments TDM Streaming file format. TDM Streaming file data can be loaded directly into National Instruments DIAdem or a custom LabVIEW application for further analysis. A *tdms* file usually does not contain time or frequency data. 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 National Instruments Hierarchical Waveform Storage file structure. NI-HWS file data can be loaded into yet other National Instruments applications, for example LabVIEW SignalExpress. See the relevant National Instruments documentation for more details on both of these file formats.


6.1.9.2 Streaming





Data streaming involves a special data file into which waveform and 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 streaming 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 [6-40](#) dialog. Using this dialog, you can also export the data to any of the file formats available [6-38](#) for storing single data sets, however, this time including multiple data sets.

While *streaming* data, the used averaging [6-26](#) algorithm automatically changes to *Summed* (mean) as opposed to employing *Continuous Averaging*.


You can choose between manual (see File Menu [6-5](#)) and automated (see Acquisition Options [6-31](#)) Streaming.

Stream File Analysis

When you open a stream file from the File Menu , the Stream File Analysis dialog automatically displays, provided opening the file and pre-processing the file header succeed.

Using the Stream File Analysis dialog, you can post-process the content of *scoBin* data streaming files that are generated during Streaming . When post-processing a stream file, you can, for example, play back and view its content using the waveform selection controls . Or, you can export the content of a stream file  to another file format. From the Stream File Analysis dialog, you can also open yet other stream files  for analysis.

File Opening


Initially, you open a stream file from the File Menu , 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.

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...  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 [6-5](#)) to a separate text file for importing it into some other data analysis software application, as opposed to exporting the entire stream file content [6-4](#). If the stream file contains spectral data, you can deactivate the Spectrum Analyzer [6-34](#) (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 [6-22](#) 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 [6-40](#)).

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* [6-26](#) control [6-26](#) value when using RAM-5000-synchronized averaging (see Acquisition Options: [6-32](#) Streaming [6-32](#) for more detail).

Export

Clicking the button, labeled "Export...", opens a file browser for exporting the entire data stream to a new file in one of the file formats available [6-38](#) for storing single data sets. However, when exporting data, multiple data sets are saved in the new file using either file format.

Note: Depending on the size of the stream file, exporting may take several minutes, in particular when choosing the ASCII text file format. A progress dialog allows you to cancel the operation if needed.

When exporting data, a settings file [6-5](#) with the extension ".scoSet" is automatically created as well.

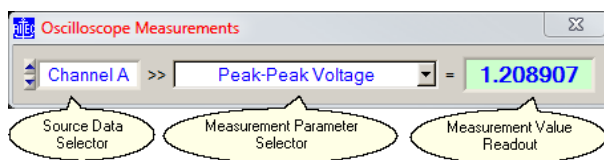
6.1.10 Measurements

The measurements presently implemented, include:

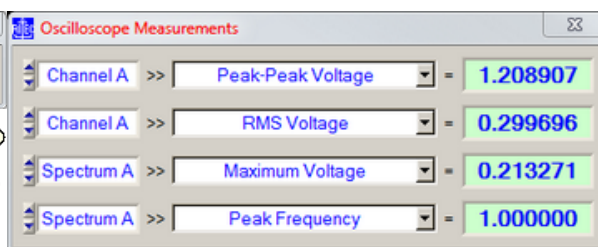
- Scalar Measurements [6-42](#)
- Measurements using Cursors [6-43](#)

When using the Spectrum Analyzer [6-34](#), you can also measure the voltage at peak frequency [6-35](#) of a spectrum and the frequency at peak voltage.

6.1.10.1 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.

6.1.10.2 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  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 , 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 μ s, dX = 5.00 μ s", or like this "Ch1: dX = 5.00 μ s, X = 9.00 μ 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 7

Instrument API

7 Instrument API

This section contains information on how to program the RAM-5000-M4-Plus using the provided instrument control and data acquisition API (Application Programming Interface).

The RAM-5000-M4-Plus Instrument API help is divided into the following sections.

- [LabVIEW Reference](#) (click to open or see *ram5Kapi_LV.pdf*)
- [C API Reference](#) (click to open or see *ram5Kapi_C.pdf*)

Version 1.1.2 Rev.0 (May 2022)

Section 8

System Checks

8 System Checks

Several internal system diagnostic procedures may be initiated from the System Checks control panel to verify that the RAM-5000-M4-Plus is working properly.

For example, to check communication with the RAM-5000-M4-Plus, you can view the power supply voltages in the instrument by selecting the tab labeled "Power Supply Voltages".

- Power Supply Voltages  8-2

8.1 Power Supply Voltages





Pressing the button labeled "Check" will initiate an internal diagnostics procedure to produce voltage readings for the various power supplies.

Section 9

Appendices

9 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*)

9.1 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.

9.2 Controlling the RAM-5000-M4-Plus via USB

Note: This section assumes that the RAM-5000-M4-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 ⁹⁻²

With certain limitations, you can control and acquire data with the RAM-5000-M4-Plus also through a USB connection. This section describes how to connect to and operate the RAM-5000-M4-Plus via USB.

Although the RAM-5000-M4-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-M4-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-M4-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-M4-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-M4-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-M4-Plus instrument control over a USB connection:

1. Install the Sealevel SeaMAX software drivers on the RAM-5000-M4-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-M4-Plus.
3. Connect the Sealevel 8126 USB module to the RAM-5000-M4-Plus using a 50-conductor ribbon cable similar to the one supplied with the 8010.

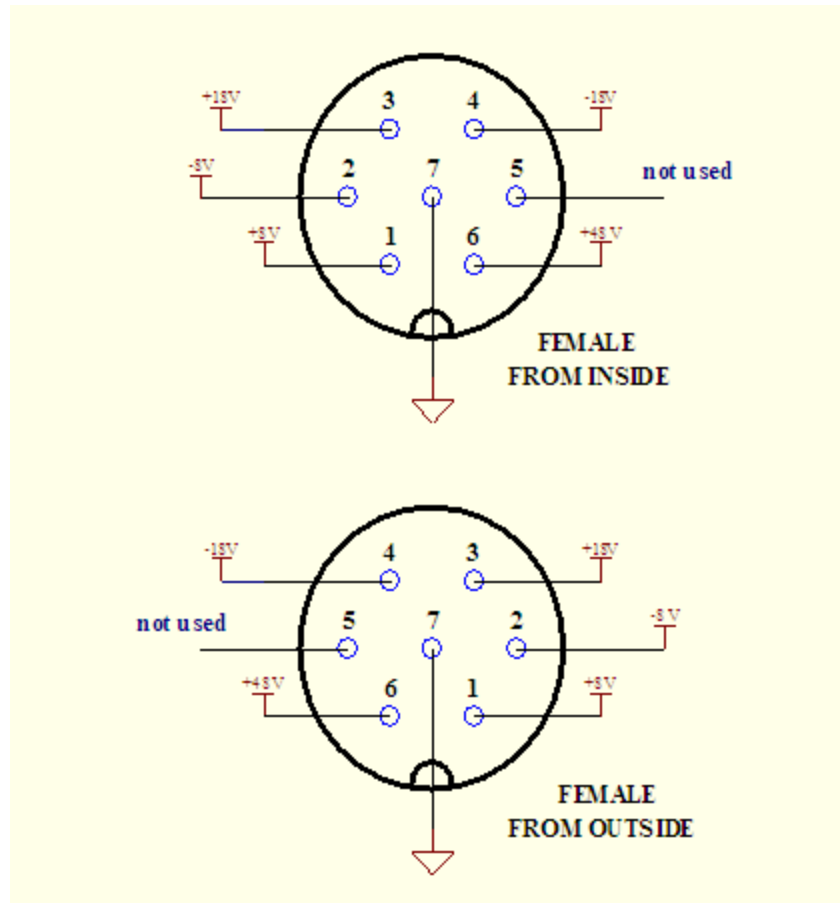
4. Connect the Sealevel 8126 USB module to the control computer using a USB device cable.
5. Verify that the 8126 is detected as such by the operating system. - Open the Device Manager and look for Sealevel 8126.
6. Launch the RAM-5000-M4-Plus User Interface as you normally would. - If the RAM-5000-M4-Plus User Interface successfully initialized I/O via the USB connection, the title bar will read "RAM-5000-M4-Plus (USB)".

How to disable an existing USB connection:

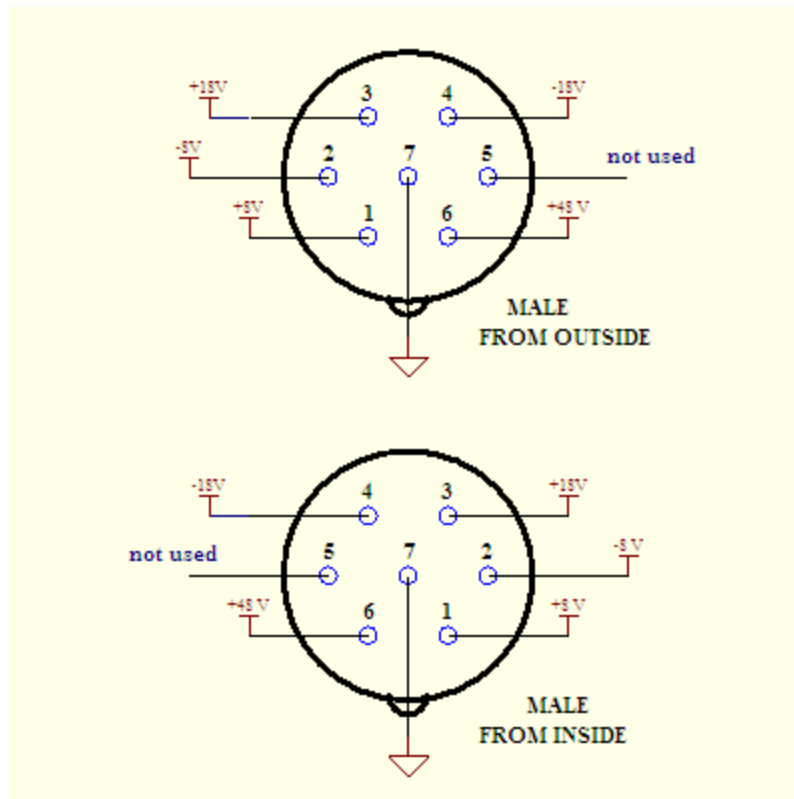
1. If applicable, shut down the RAM-5000-M4-Plus User Interface as you normally would.
2. Unplug either end of the USB device cable that connects the Sealevel 8126 USB module to the control computer.
3. Unplug the ribbon cable from the RAM-5000-M4-Plus that connects to the Sealevel 8126 USB module.
4. Insert the ribbon cable coming from the Sealevel 8010 interface inside the control computer into the RAM-5000-M4-Plus.
5. Launch the RAM-5000-M4-Plus User Interface as you normally would. - If the RAM-5000-M4-Plus User Interface successfully initialized I/O via the 8010 interface, the title bar will not show anything in parentheses.

9.3 External Power Output Connectors

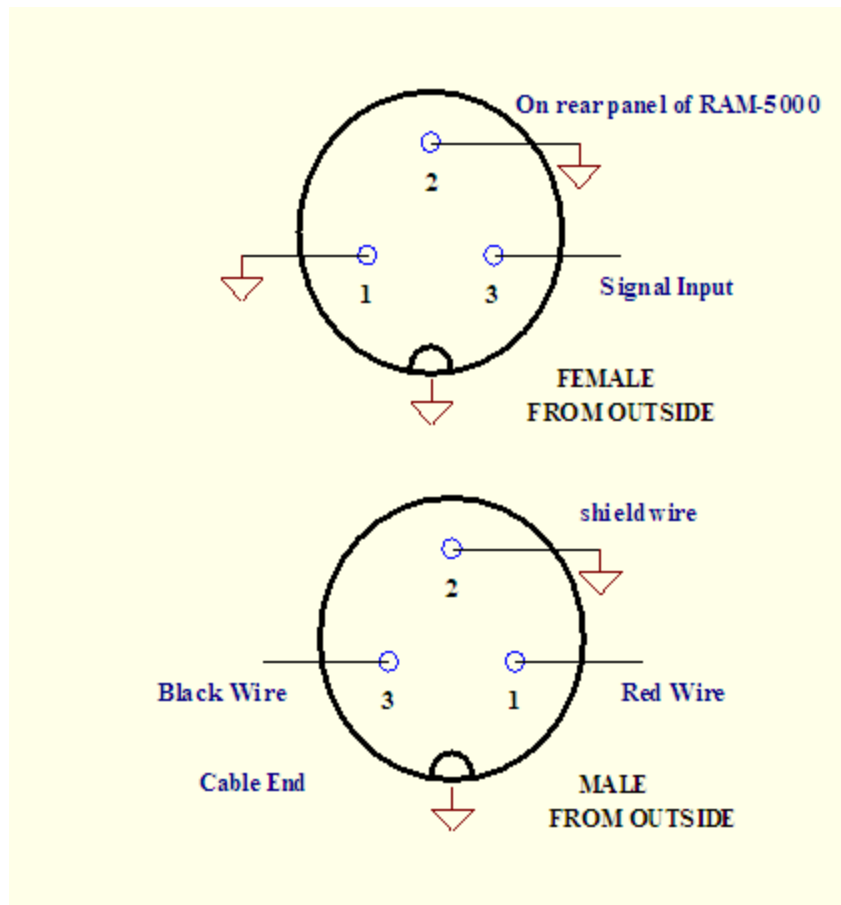
There is a pair of auxiliary power connectors located on the rear panel of the RAM-5000 instrument to power peripherals such as a clamped diplexer or preamplifier. For safety reasons, the connectors on the instrument are female polarity. With a powered peripheral, we will supply a 7-pin connector with 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:



9.4 Warranty

All RITEC instruments are warranted against defects in material and workmanship for a period of one year after date of original shipment. RITEC agrees to repair or replace any assembly or component found to be defective after normal use during this period. RITEC's obligation under this warranty is limited solely to repairing any such instrument that, in RITEC's sole opinion, proves to be defective within the scope of the warranty when returned to the factory. Transportation to the factory is to be prepaid by the purchaser. Shipment should not be made without prior authorization by RITEC. Please contact the factory for a return merchandise authorization (RMA) number.

This warranty does not apply to any products repaired or altered by persons not authorized by RITEC, or not in accordance with instructions furnished by RITEC. If the instrument is defective because of misuse, improper repair, or abnormal conditions or operations, repairs will be billed at cost.

RITEC assumes no responsibility for its product being used in a hazardous or dangerous manner either alone or in conjunction with other equipment. High voltage used in some instruments may be dangerous if misused. Special disclaimers apply to these instruments. RITEC assumes no liability for secondary charges or consequential damages and, in any event, RITEC's liability for breach of warranty under any contract or otherwise shall not exceed the purchase price of the specific instrument shipped and against which a claim is made.

Any recommendations made by RITEC for use of its products are based upon tests believed to be reliable, but RITEC makes no warranty of the results to be obtained. This warranty is in lieu of all other warranties, expressed or implied, and no representative or person is authorized to represent or assume for RITEC any liability in conjunction with the sale of our products other than set forth herein.

This warranty covers only items manufactured by RITEC. It specifically excludes all items sold by RITEC that were manufactured by other companies. All of these items are subject to their original individual manufacturer's warranty. Any claims for defective merchandise should be made to the original manufacturer for these items.

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