

MLSSA RCAI

Remote Controlled Analog Interface

Reference Manual

Version 2.0

DRA Laboratories

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Introduction

The *MLSSA Remote Controlled Analog Interface (RCAI)* is an option that you either purchased with *MLSSA* or, separately. If you purchased the *RCAI* with a new *MLSSA* system or, if for any other reason you are unfamiliar with *MLSSA*, you should first read the Installation section of the *MLSSA Reference Manual* and completely install *MLSSA*. After installing *MLSSA* and after having acquired a basic understanding of how to use *MLSSA*, refer back to this manual to install the *RCAI*. *MLSSA* software commands specific to the *RCAI* are documented in this manual. All the other *MLSSA* commands and the basic measurement procedures are documented in the *MLSSA Reference Manual*.

The *MLSSA RCAI* is designed to be used with *MLSSA* 2000 cards. Unlike older *MLSSA* cards, *MLSSA* 2000 cards supply the pink-filtered MLS test stimulus and only *MLSSA* 2000 cards supply +12 VDC to power the *RCAI*.

The *RCAI* supports common ground power amplifiers rated at up to 800 watts. Note that only common ground power amplifiers can be used with the *RCAI*. Power amplifiers with floating outputs cannot be used. The term “common ground” means that the power amplifier’s input signal ground is common with its output ground terminal. The power amplifier you select should also offer an unbalanced input. A balanced input can be used with a suitable unbalanced-to-balanced adaptor but only if the balanced input’s ground connection is truly in common with the output ground terminal.

MLSSA software versions 10WI and above are required to use the *RCAI*. The software automatically detects the number of units connected at start up. Up to four (4) *RCAI* units may be daisy chained to provide up to 16 inputs and/or control up to four (4) power amplifiers from a single *MLSSA* 2000 card.

You can select one of four (4) line-level inputs and one of three (3) test signals via simple software commands. Test signals include the Pink-MLS and White-MLS, both generated by *MLSSA* 2000 cards, as well as an optional Aux signal source that can be supplied by an external signal generator or music source.

Some *MLSSA* commands automatically make use of the *RCAI*. For example, the Reference Go command automatically configures it to measure the frequency response of your power amplifier and store the result as a reference. Whenever Reference Go is executed, a precision 13-dB loopback attenuator is automatically inserted into the signal chain and is automatically accounted for by the software in all subsequent analysis. The 13-dB loopback attenuator protects the *MLSSA* input from overload and possible damage caused by high voltages often encountered when using high-power amplifiers. Using simple software commands, your power amplifier can optionally be bypassed for making direct measurements, if desired.

Loudspeaker frequency response and impedance measurements can be performed in rapid succession and displayed simultaneously. The Go Impedance command allows you to perform an impedance measurement at any time, regardless of the current *MLSSA* setup.

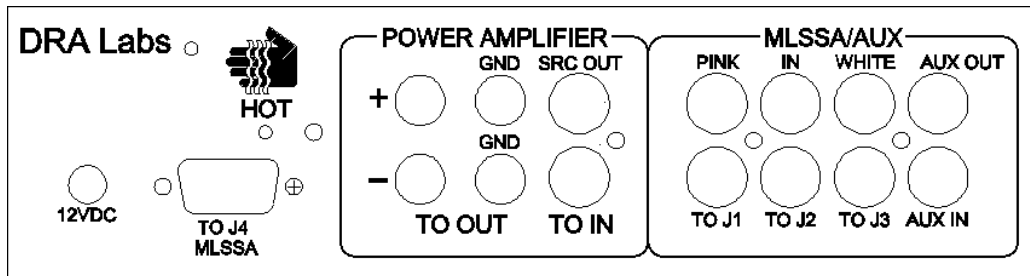
Two daisy-chained *RCAI* units permit convenient software-controlled switching between measuring locally or, at a remote location. For example, a local *RCAI* placed near *MLSSA* is configured for direct T/S parameter measurements using *MLSSA SPO*. A second *RCAI*, located in an anechoic chamber, interfaces the same *MLSSA* system to a high-powered amplifier and a turntable for measuring anechoic loudspeaker frequency response. This arrangement allows you to easily switch from measuring driver parameters locally, without a power amplifier, to performing loudspeaker measurements using a high-power amplifier in the anechoic chamber. You switch between these locations using only a few special *MLSSA* software commands. The later sections of this manual document the *MLSSA* commands required to control up to four (4) *RCAI* units.

Turntable control is provided through a DB-9 connector located on the front panel of the *RCAI*. High-current line drivers permit long cable runs, up to 50 meters in length.

The *RCAI* allows production QC macros to be written that do not require the operator to swap cables or operate a manual switch box. Unlike a manual switch box, the *RCAI* is 100% controlled by the macro which increases throughput and protects the *MLSSA* 2000 card and associated equipment from possible damage due to operator errors.

Rear Panel Description

The rear view of the *RCAI* is shown in the figure below.



Rear View of *MLSSA RCAI*

CAUTION: The area labeled “HOT” can rise in temperature to as high as 85° C before an internal thermal protection switch opens to prevent possibly higher temperatures. You should avoid touching this area when performing impedance measurements through your power amplifier. The entire rear panel acts as a heat sink for an internal precision 75-ohm power resistor used for performing impedance measurements. This precision, 0.1% tolerance, 10 watt power resistor is mounted just behind the area labeled “HOT”, which can get quite hot to the touch. The power resistor dissipates significant power only during impedance measurements using your power amplifier. Avoid prolonged and/or highly repetitive impedance measurements at high power levels to avoid overheating. If the thermal protection switch does open, as indicated by no sound coming from your loudspeaker during impedance measurements, allow the unit to cool down for at least 5 minutes. The thermal sensor will automatically reset itself and restore normal operation when the rear panel temperature falls below 70° C.

EXTERNAL POWER CONNECTOR: The connector labeled “12VDC” should not be connected when using the *RCAI* with *MLSSA 2000* cards, which supply power through the male DB-9 connector labeled “TO J4 MLSSA”. To use the *RCAI* with older *MLSSA* cards, you must supply regulated +12 volts DC +/- 10% with 150-ma capacity per connected *RCAI* to this connector using a commonly available external power supply. If you intend to use the *RCAI* with an older *MLSSA* card, you must first remove the

jumper installed at JP2, located inside the *RCAI*. Otherwise, you could damage your old *MLSSA* card. Turn over the *RCAI* and remove the two screws holding the upper and lower halves of the plastic cover in place. Return the *RCAI* to the upright position and remove the top cover. JP2 is located in the right-rear corner of the circuit board. Remove the jumper. Reassemble the *RCAI*. With jumper JP2 removed, power is supplied to the *RCAI* using an external +12 volt DC power supply. Note that any additional units daisy chained to the first unit will be powered through the DB-9 connector, located on the rear panel of the *RCAI*. Any additional *RCAI* units must have their jumpers installed at JP2.

The male DB-9 connector labeled “TO J4 *MLSSA*” is used to connect the *RCAI* to J4 on the rear L-bracket of *MLSSA 2000* cards using the supplied male DB-9 to female DB-9 extension cable. All digital communications signals pass to and from the *RCAI* through this connection, as well as +12 volt DC power supplied by *MLSSA 2000* cards.

The area labeled “POWER AMPLIFIER” includes the connectors used to interface the *RCAI* to your power amplifier. The connectors labeled ‘+’ and ‘—’ are banana jacks that are connected to the output terminals of your common ground power amplifier through heavy-gauge speaker wire, not supplied. The banana jack labeled ‘—’ must connect to the grounded output terminal of your power amplifier. The banana jack labeled ‘+’ must connect to the hot output terminal of your power amplifier. Reversing polarity may result in severe damage to the *RCAI*, connecting cables, or your power amplifier.

The two banana jacks labeled “GND” are analog ground and one must be connected to the grounded output terminal of your common ground power amplifier. Thus, the grounded output terminal of your power amplifier should be connected to *both* the banana jack labeled ‘—’ as well as to one of the two banana jacks labeled “GND”, using two separate wires. This seemingly redundant ground connection is required to avoid ground loops and to ensure full accuracy of *MLSSA* impedance measurements. The other banana jack labeled “GND” is a spare that can be used to ground other equipment, if desired.

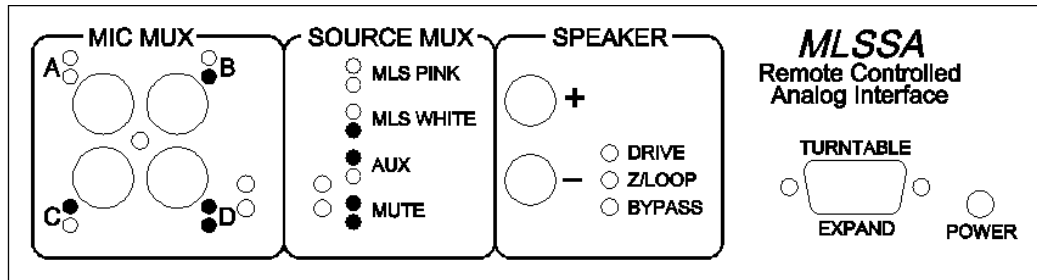
The phono connector labeled “TO IN” is an unbalanced line level output used to drive your power amplifier’s unbalanced line level input. The phono connector labeled “SRC

OUT” outputs the same signal and is used to perform direct measurements that bypass your power amplifier, including direct impedance measurements.

The area labeled “MLSSA/AUX” includes phono connectors required to interface the *RCAI* to the analog input and outputs of your *MLSSA 2000* card. These are labeled “TO J1”, “TO J2” and “TO J3” where each label refers to the corresponding phono connector located on the rear L-bracket of your *MLSSA 2000* card. The connector labeled “AUX IN” can be used to supply an optional auxiliary test signal from an external signal generator or music source. The top row of connectors labeled “PINK”, “IN”, “WHITE” and “AUX OUT” are used to daisy chain to the next *RCAI*, if more than one is to be connected. Otherwise, these connectors should be left unconnected.

Front Panel Description

The front view of the *MLSSA RCAI* is shown in the figure below.



Front View of *MLSSA RCAI*

The area labeled “MIC MUX” includes four phono connectors that connect to the outputs of your microphone preamps or, to other line-level signals that need to be routed to the *MLSSA* input. Note that these line-level inputs are not buffered. They are routed by high quality signal relays directly to the input of your *MLSSA* 2000 card, which has a nominal input impedance of about 13 kohms. To avoid crosstalk and loading errors, these inputs should be driven only from low impedance sources having output impedances of at most a few hundred ohms and preferably less. The currently selected mic mux input is indicated by a binary-coded vertical pair of green LEDs, located in the lower-right corner of the MIC MUX area. The binary code for each mic mux input is shown next to each of the input connectors labeled A, B, C and D.

The area labeled “SOURCE MUX” contains no connectors but displays the currently selected test signal via another vertical pair of binary-coded green LEDs. The four possible sources are shown, each next to its corresponding binary code. **MLS PINK** indicates that the pink-filtered MLS generated on your *MLSSA* 2000 card is the currently selected test stimulus. **MLS WHITE** indicates that the white or unfiltered MLS generated on your *MLSSA* 2000 card is the currently selected test stimulus. **AUX** indicates that an optional external signal source, from your external signal generator or music source, is the currently selected test stimulus. The **MUTE** option means that no test signal from any source is currently selected and that the test stimulus is essentially

a dead short to ground. The MUTE state is always entered automatically whenever the *RCAI* is powered up. This action avoids accidental damage to your loudspeaker or other test load that may be connected to the *RCAI* or, to your power amplifier. The MUTE state is also used to disable the drive from all but the currently active *RCAI*, when two or more *RCAI* units are daisy chained together.

The area labeled “SPEAKER” contains two banana jacks that connect the *RCAI* to your loudspeaker or other load under test, when performing power amplifier driven measurements.

There are three red status LEDs within the SPEAKER area. The LED labeled “DRIVE” is turned on whenever the power amplifier is connected to drive the loudspeaker. When the DRIVE light is off, the connection to the loudspeaker is broken in the ‘+’ lead only. The ‘—’ lead is always connected. The LED labeled “Z/LOOP” is on whenever the speaker is driven through an internal precision 0.1% tolerance, 75-ohm, 10-watt series power resistor. When this LED is on, the 75-ohm power resistor is in series with ‘+’ lead. Note that during reference loopback measurements, the Z/LOOP light is turned on while the DRIVE light is turned off. During power amplifier impedance measurements, both the Z/LOOP and DRIVE lights are turned on.

The LED labeled “BYPASS” is applicable whenever there are two or more *RCAI* units daisy chained together. When turned on, the BYPASS light indicates that that particular *RCAI* is passing along one of the mic mux inputs, the reference loopback signal or, the impedance signal from the next higher *RCAI* up the daisy chain. If the next higher *RCAI* also has its BYPASS light turned on, then it is also passing along these signals from the next higher unit, etc.

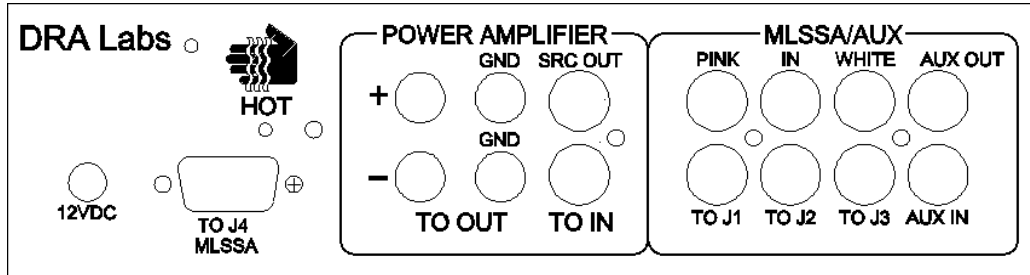
The BYPASS light has a completely different meaning when both it and the Z/LOOP LED are on simultaneously. In that case, the *RCAI* is configured to perform either a direct loopback reference measurement or, a direct impedance measurement. Direct measurements bypass the power amplifier connected to that particular *RCAI*. Direct measurements connect the selected stimulus source signal (pink-MLS, white-MLS or Aux) directly to the unit under test through the connector labeled “SRC OUT” located on the rear panel of the *RCAI*. In this exceptional case, when both the BYPASS and

Z/LOOP LEDs are lighted, the *RCAI* is not passing signals from higher *RCAI* units, but rather the power amplifier is being bypassed.

As its name implies, the female DB-9 connector labeled "TURNTABLE / EXPAND" has two functions. First, this connector is used to daisy chain control signals and +12 VDC power to the next *RCAI* unit, if more than one *RCAI* is connected. To daisy chain to the next *RCAI*, a DB-9 extension cable is run from the TURNTABLE/EXPAND connector of one *RCAI* to the connector labeled "TO J4 MLSSA" located on the rear panel of the next *RCAI* in the daisy chain. Further units are daisy chained in the same way up to a maximum of four (4) units. On the last *RCAI* in the daisy chain, the TURNTABLE/EXPAND connector can be used to control a turntable through the Macro Command Signal and Macro Command Wait commands.

MLSSA / RCAI Connections

This section explains how to connect the *RCAI* to your *MLSSA* 2000 card. All connections between your *MLSSA* 2000 card and the *RCAI* are made on the rear panel, which is shown below for reference.



Rear View of *MLSSA RCAI*

A male DB-9 to female DB-9 extension cable is supplied with your *RCAI*. Plug the male DB-9 end of the cable into J4 located on the rear of the *MLSSA* 2000 card. Plug the female DB-9 end of the cable into the connector labeled "TO J4 MLSSA" located on the rear panel of the *RCAI*. Tighten the screws on both connectors.

A triple color-coded (red, white and yellow) phono patch cable is supplied with your *RCAI*. Locate one end of the triple color-coded cable. Plug the red plug into J1 (top phono connector) located on the rear of the *MLSSA* 2000 card. Plug the white plug into J2 (middle phono connector). Plug the yellow plug into J3 (bottom phono connector). Locate the other end of the triple color-coded cable and turn attention to the rear panel of the *RCAI*. Plug the red plug into the phono connector labeled "TO J1" located in the area labeled "MLSSA/AUX". Plug the white plug into the connector labeled "TO J2". Plug the yellow plug into the connector labeled "TO J3".

If you intend to use an auxiliary test signal, obtain an ordinary phono patch cord, not supplied. Plug one end of this patch cord into the connector labeled "AUX IN", located on the rear panel of the *RCAI*. Plug the other end of the patch cord into the output of an external signal source, which could be a signal generator or music source.

Daisy Chaining Additional Units

Additional *RCAI* units, if required, are daisy chained together as follows. Find the male DB-9 to female DB-9 extension cable supplied with your second *RCAI*. Plug the male DB-9 end of the cable into the connector labeled "TURNTABLE / EXPAND" located on the front panel of the first *RCAI*. Plug the female DB-9 end of the cable into the connector labeled "TO J4 MLSSA" located on the rear panel of the second *RCAI*. Tighten the screws on both connectors.

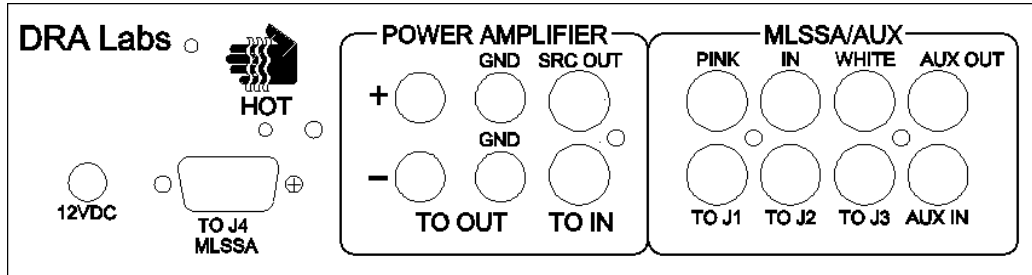
Locate the triple color-coded phono patch cable (red, white and yellow) supplied with your second *RCAI*. Plug the red plug into the connector labeled "PINK" located on the rear panel of the first *RCAI* inside the area labeled "MLSSA/AUX". Plug the white plug into the connector labeled "IN". Plug the yellow plug into the connector labeled "WHITE". Note that the label "WHITE" on the *RCAI* refers to the white or unfiltered MLS and does not refer to the plug color. Next, locate the other end of the triple color-coded cable and turn attention to the rear panel of the second *RCAI*. Plug the yellow plug into the connector labeled "TO J3" on the rear panel of the second *RCAI*. Next, plug the white plug into the connector labeled "TO J2" of the second *RCAI*. Finally, plug the red plug into the connector labeled "TO J1" of the second *RCAI*.

If you are not using the Aux input of the first *RCAI* or, if you do not need to transmit the Aux signal to the second *RCAI*, skip this paragraph. Locate an ordinary phono patch cord, not supplied. Plug one end of this patch cord into the connector labeled "AUX OUT" located on the rear panel of the first *RCAI*. Plug the other end of the patch cord into the connector labeled "AUX IN" located on the rear panel of the second *RCAI*.

Up to two more *RCAI* units may be daisy chained, in the same way that you connected the first unit to the second, up to four (4) units maximum.

Power Amplifier / RCAI Connections

This section explains how to connect the *RCAI* to your power amplifier. All connections between your power amplifier and the *RCAI* are made on the rear panel, which is shown below for reference.



Rear View of MLSSA RCAI

The *RCAI* supports only common ground power amplifiers rated at up to 800 watts. A solid-state unit with output short-circuit protection and a low output impedance is recommended.

CAUTION: Only common ground power amplifiers can be used with the *RCAI*. Power amplifiers offering floating outputs cannot be used. The term “common ground” means that the power amplifier’s input ground is common with its output ground terminal, that they are internally connected. The power amplifier you select should also offer an unbalanced input. A balanced input can be used, however, by obtaining a commonly available unbalanced-to-balanced adaptor, provided the balanced input’s ground connection is actually in common with the output ground terminal.

Using a phono patch cable, not supplied, connect your power amplifier’s unbalanced input to the connector labeled “TO IN” located on the rear panel of the *RCAI* in the area labeled “POWER AMPLIFIER”.

Your power amplifier’s output terminals need to be connected to the ‘+’ and ‘—’ banana jacks located on the rear panel of the *RCAI* in the area labeled “POWER AMPLIFIER”.

Use 12-gauge speaker wire, not supplied, and terminate with the supplied heavy-duty banana plugs. The hot power amplifier output terminal needs to connect to the '+' banana jack while the grounded power amplifier output terminal needs to connect to the '—' banana jack.

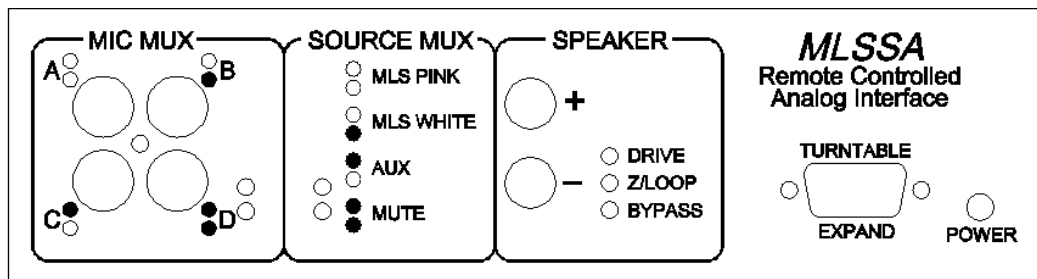
CAUTION: The banana jack labeled '—' must connect to the grounded output terminal of your power amplifier. The banana jack labeled '+' must connect to the hot output terminal of your power amplifier. Reversing polarity may result in severe damage to your *RCAI*, connecting cables, or your power amplifier.

The *RCAI* requires a separate analog ground wire which is connected from the grounded output terminal of your power amplifier to one of the two banana jacks labeled "GND" located on the rear panel of the *RCAI*. This analog ground connection should be made with 18-gauge wire, not supplied, and terminated with one of the heavy-duty black banana plugs supplied with the *RCAI*. Connect the grounded output terminal of your power amplifier to one of the two banana jacks labeled "GND" on the rear panel of the *RCAI*. The extra banana jack labeled "GND" is a spare that can be used to ground other equipment, if desired.

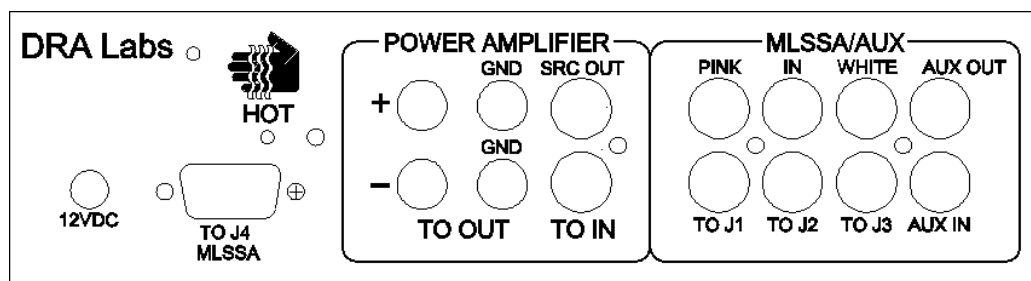
WARNING: This seemingly redundant ground connection from the *RCAI* to your power amplifier's output ground terminal is important. It should not be omitted as it prevents ground loops and ensures the highest accuracy of loopback reference measurements and impedance measurements.

Connecting a Loudspeaker or other DUT to the RCAI

For power amplifier driven measurements, connections to a loudspeaker, speaker driver or other test load are made using the two banana jacks labeled '+' and '-' located on the front panel of the *RCAI*, shown below for reference. Use 12-gauge speaker wire, not supplied, and terminate with the heavy-duty banana plugs supplied with the *RCAI*.



Front View of MLSSA RCAI



Rear View of MLSSA RCAI

If you wish to perform direct measurements that bypass your power amplifier, you must connect the loudspeaker, speaker driver or other load under test to the phono connector labeled "SRC OUT" located on the rear panel of the *RCAI* in the area labeled "POWER AMPLIFIER". Use this connector to drive the inputs of equalizers or other line level devices that you might wish to measure. In such cases, connect the output of the equalizer or, other line level device under test, to one of the four (4) line-level inputs located on the front panel of the *RCAI* in the area labeled "MIC MUX".

When using the “SRC OUT” connector for direct impedance measurements, keep in mind that the input impedance of your power amplifier is effectively in parallel with the test load impedance. If the input impedance of your power amplifier is 10K ohm or higher, impedance measurement errors will be negligible when measuring low impedance devices such as typical speaker drivers. However, if you are measuring higher impedance drivers and/or the input impedance of your power amplifier is unusually low, it's best to temporarily unplug the “TO IN” connector that drives your power amplifier's input when making direct impedance measurements. Doing so avoids the possibility of your power amplifier's input impedance causing an impedance measurement error.

Long Cable Runs — DB-9 Extension Cables

The DB-9 extension cable supplied with your *RCAI* is 3 meters long. This specially modified cable has pin 7 removed from the male end to prevent capacitive loading of the digital MLS generator on the *MLSSA* 2000 card. Commonly available DB-9 extension cables can be used to increase the total cable length but they should not replace the modified cable supplied with your *RCAI*. Instead, extension cables should be daisy chained to the modified cable to increase the total cable length. Connect the supplied 3-meter cable directly to J4 of your *MLSSA* card and then connect the extension cable to the free end of the modified cable. This arrangement ensures that J4 pin 7 will not experience any capacitive loading. However, when connecting the second, third or fourth *RCAI* unit or when connecting a turntable, you can safely replace the modified cable with a standard DB-9 extension cable.

Standard DB-9 extension cables are manufactured by ASSMANN and are available from electronics distributors including Digi-Key at www.digikey.com.

The triple color-coded phono cable supplied with your *RCAI* is 2 meters long. This is a standard Audio/Video (A/V) style cable, which is available almost everywhere in longer lengths with the standard A/V color-coding: red, white and yellow. If a sufficiently long standard triple color-coded A/V cable is unavailable, individual phono patch cords of sufficient length may be substituted. In that case, of course, more care must be exercised to ensure that your connections are made correctly.

Replacing the Internal Fuse

The *RCAI* protects its high quality relays from excessive current with a 10-amp fast-blow fuse. This fuse is located in a socket near the center of the internal circuit board. To access and replace this fuse, remove the two mounting screws located under the unit and then remove the top cover.

Overview of Software Commands

MLSSA software versions 10WI and above provide integrated software control of the *RCAI*. You control the operation of the *RCAI* through the Acquisition Interface commands, described in this section. Refer to Appendix B of the *MLSSA Reference Manual*, versions 10WI and above, for a complete listing of the Acquisition Interface commands menu trees.

The four-input line-level multiplexer is controlled through the Acquisition Interface Mic-mux command. Enter one of the four mic mux inputs labeled A, B, C and D located on the left side of the front panel of the *RCAI*. Your current selection is indicated by the pair of binary-coded green LEDs located in the lower-right corner of the area labeled "MIC MUX" on of the front panel.

The test signal is selected through the Acquisition Interface Source command. You can choose Pink, White, Aux or Mute. Your current selection is indicated by the pair of binary-coded green LEDs located in the SOURCE MUX area of the front panel. The Pink option is suggested for all acoustic measurements including loudspeaker frequency response, loudspeaker sensitivity, room frequency response and room acoustical parameters. The White option is suggested for all electronic measurements. Note, however, that whatever source you select using this command, it does not apply to reference loopback and impedance measurements. The source used for reference loopback and impedance measurements is controlled by the Acquisition Interface Options Z/loop-source command. Only the White and the Pink sources are available. It is strongly suggested that you use the White source for all reference loopback and impedance measurements. This is the default so there is no need to change it. When performing a reference loopback measurement through the Reference Go command in the frequency domain, the *RCAI* will temporarily switch to the Z/loop source and this change will be indicated by the binary-coded LEDs located in the SOURCE MUX area. After the reference measurement is completed, the *RCAI* will automatically revert back to supplying whatever test signal you had previously selected via the Acquisition Interface Source command. Similarly, whenever *MLSSA* is configured to measure impedance, the *RCAI* will supply the test stimulus defined by the Acquisition Interface

Options Z/loop-source command. Otherwise, the *RCAI* will supply the test stimulus defined by the Acquisition Interface Source command.

Note that *MLSSA* automatically turns pink filter equalization on or off as required when performing various measurements, including loopback reference measurements and impedance measurements. Thus, there is no need to manually enable or disable pink filter equalization through the Acquisition Equalization command when using the *RCAI*. Generally, you should *not* execute the Acquisition Equalization command whenever the *RCAI* is connected because doing so is unnecessary and may result in an incorrect measurement result.

The Acquisition Interface Drive command allows you to select either Power-amp or Direct drive. With Power-amp drive selected, the Reference Go command automatically measures the power amplifier's frequency response and stores it as the main reference. This loopback reference measurement is made through a precision 13-dB attenuator allowing safe reference measurements of high-powered amplifiers rated at up to 800 watts. The *MLSSA* software automatically accounts for the 13 dB of attenuation in all subsequent analysis.

In the Direct drive mode, reference loopback measurements are taken directly from the *MLSSA* output, thus bypassing the internal 13-dB attenuator and the power amplifier. In Direct drive mode, the LED labeled "DRIVE" is always off, indicating that the power amplifier is always disconnected from the '+' banana jack located on the front panel of the *RCAI*. When in the Direct drive mode, you must connect the input of the device you wish to measure to the "SRC OUT" connector located on the rear panel of the *RCAI*. The output of the device you wish to measure is then connected to one of the mic mux inputs located on the front panel. To measure impedance in the Direct drive mode, you connect the load directly to the "SRC OUT" connector.

When using the "SRC OUT" connector for direct impedance measurements, keep in mind that the input impedance of your power amplifier is effectively in parallel with the test load impedance. If the input impedance of your power amplifier is 10K ohm or higher, impedance measurement errors will be negligible when measuring low impedance devices such as typical speaker drivers. However, if you are measuring

higher impedance drivers and/or the input impedance of your power amplifier is unusually low, it's best to temporarily unplug the "TO IN" connector that drives your power amplifier's input when making direct impedance measurements. Doing so avoids any possibility of direct impedance measurement errors due to your power amplifier's input impedance.

In the frequency domain, the Go Impedance command can be invoked even when *MLSSA* is configured to measure loudspeaker frequency response or sensitivity. This command temporarily configures the *RCAI* to measure the impedance of the loudspeaker, which can be stored as an overlay and later displayed simultaneously with the loudspeaker's frequency response. See "Sensitivity / Impedance Measurement Procedure" below for details. After the impedance measurement is completed, *MLSSA* re-configures the *RCAI* to continue making frequency response measurements or, whatever the current *MLSSA* setup dictates, when the next Go Once command is executed.

To ensure accurate impedance and loudspeaker sensitivity measurements, you must first perform a reference loopback measurement using the Reference Go command from the frequency domain. Once measured and stored, the same reference corrects both impedance and sensitivity measurements for your power amplifier's gain and frequency response. The reference measurement also corrects for the frequency response of the antialiasing filter on the *MLSSA* 2000 card. Whether you have selected the Power-amp drive mode or the Direct drive mode, you first need to execute the Reference Go command before performing impedance and/or sensitivity measurements. Furthermore, if you switch from Power-amp drive to Direct drive, you must repeat the Reference Go command. Similarly, switching from Direct drive to Power-amp drive requires a new reference measurement. The software will beep and warn you if you attempt to use a reference not taken from the currently selected *RCAI* unit and with the currently selected drive mode. In that case, the main reference will not be applied to the measurement and you will need to re-execute the Reference Go command to obtain a fresh main reference.

The Acquisition Interface Reset command resets and re-programs all connected *RCAI* units. Use this command if you connect or disconnect any *RCAI* units after starting *MLSSA* and wish to reset and re-program them without Quitting *MLSSA* and re-starting

Assigning Microphones to Mic Mux Inputs

MLSSA must know the calibration data for each connected microphone/preamp combination to perform calibrated SPL and sensitivity measurements. Microphone calibration data and preamp gain data are entered into the Library Microphones screen, as in all previous *MLSSA* software versions. With an *RCAI* connected, however, *MLSSA* must also know the identity of the microphone and preamp connected to each *RCAI* mic mux input that you intend to use. You supply this information through the Library Microphones Assign command, which assigns a unique microphone number to the specified *RCAI* mic mux input. When one or more *RCAI* units are connected, the Library Microphones Select command is no longer available. Instead, microphone selection is done automatically by the software whenever you change the mic mux input through the Acquisition Interface Mic-mux command. If you disconnect all *RCAI* units and then re-start *MLSSA*, the Library Microphones Select command is again available to manually select the microphone connected to the *MLSSA* input while the Library Microphones Assign command is no longer available.

With one or more *RCAI* units connected, you use the Library Microphones Define and Library Microphones Assign commands to configure *MLSSA* to use your specific microphones and microphone preamps. For example, consider that you are using only one microphone/preamp and have one *RCAI* connected. First, execute Library Microphones Define and enter an unused microphone number between 1 and 16. For example, choose microphone #1 by entering a '1'. Next, enter the microphone and preamp data, as prompted by the command. At a minimum, you must enter the microphone's sensitivity, in units of millivolts/Pascal (mV/Pa), as well as the exact gain of your preamp, in units of decibels (dB). After defining microphone #1, the next step is to assign it to one of the mic mux inputs of your *RCAI*. To do this, execute the Library Microphones Assign command and enter the mic mux input (A, B, C or D) that your microphone preamp's output is currently driving. In this example, enter input 'A'. Press the Enter key and then enter the microphone number (1 thru 16), '1' in this example. Press Esc to return to the main *MLSSA* menu and then execute the Acquisition Interface Mic-mux command, selecting the A input. You are now ready to

perform calibrated sensitivity or SPL measurements using the microphone/preamp combination connected to mic mux input A.

Adding a second, third or fourth microphone/preamp is simple. Execute the Library Microphones Define command and enter an unused microphone number between 1 and 16 followed by the microphone and preamp data for the new microphone/preamp combo. Next, execute the Library Microphones Assign command to assign the *RCAI* mic mux input connected to the output of the new microphone/preamp; to the microphone number you just defined. After having defined and assigned as many microphone/preamps as you require, press Esc to exit the Library Microphones screen and then change your microphones through the Acquisition Interface Mic-mux command. When executing this command, *MLSSA* will automatically know the correct sensitivity and preamp gain to apply to your measurements. Furthermore, the Go Spatial-average command will automatically step through each connected microphone/preamp, in turn, and properly account for variations in the sensitivities and preamp gains of each connected microphone. See the “Spatial Average Measurement Procedure” section below for details.

When executing the Library Microphones Assign command in cases where two or more *RCAI* units are connected, you will need to specify *both* the *RCAI* unit number (1, 2, 3, or 4) *and* the mic mux input (A, B, C or D). For example, if your microphone preamp is connected to the A input of the first *RCAI* you would enter “1A”. You would enter “2B”, for example, if your preamp were connected to the B input of the second *RCAI*.

The Library Microphones screen displays a complete list of all the currently available *RCAI* mic mux inputs as well as the microphone numbers assigned to them. If no microphone is currently assigned to one of the mic mux inputs, *MLSSA* will display a microphone number of zero (0). You can easily re-assign any mic mux input to any defined microphone number using the Library Microphones Assign command. Repeated use of this command allows you to re-assign all of your mic mux inputs to different microphone/preamps, if desired. Note, however, that *MLSSA* will not allow you to assign the same microphone number to more than one mic mux input.

Power Amplifier Impedance Measurement Procedure

Start *MLSSA* with setup file *IMP1K.SET*, *IMP20K.SET* or *IMP20KHR.SET* depending upon the frequency range and resolution needed. You can also load one of these setup files through the Setup Load command. Execute Acquisition Interface Drive and select the Power-amp drive option. Execute FFT Bypass followed by Reference Go. *MLSSA* will measure the transfer function of your power amplifier through the internal 13-dB attenuator and store it as the reference. Due to the 13-dB attenuator, the resulting curve will not be at unity but below unity at a level of 0.222. This is normal and does not indicate a malfunction. Note that when measuring impedance using the *RCAI*, the sense resistor in series with the load is within 0.1% of exactly 75.0 ohms. The setup files mentioned above automatically enter a series resistance value of 75 ohms. If, however, you ever happen to execute the FFT Mode Impedance command in the time domain, always remember to enter a series resistance value of exactly 75 ohms for accurate impedance measurements using the *RCAI*.

Connect the loudspeaker or other load to the '+' and '-' banana jacks located on the front panel of the *RCAI*. Execute the Go Once command to measure and display its impedance. Note that when using a power amplifier to measure impedance, an internal, precision, 75-ohm, 0.1% tolerance, 10-watt power resistor is in series with the load through the '+' lead. This resistor can overheat when measuring impedance at high power levels and/or over extended periods. If the rear panel temperature rises above 85° C, a thermal protection sensor will break the connection to the load making further impedance measurements impossible. It may require several minutes for this thermal sensor to reset itself as the rear panel cools down to below 70° C. During this reset period, you will not be able to perform impedance measurements and/or loopback reference measurements.

For higher accuracy impedance measurements, you can optionally correct for the residual impedance of your speaker cables as follows: Short together the ends of the speaker cables that run from the *RCAI* to the loudspeaker. (WARNING: Never try this when *MLSSA* is not in the Impedance FFT mode. Otherwise, the 10-amp relay protection fuse located inside the *RCAI* may blow. Note that whenever the red Z/LOOP LED is lit, there is no danger of blowing the fuse.) With the speaker-cable ends shorted

together, execute Go Once followed by Reference Auxiliary Store. The residual complex impedance of your speaker cables is now stored as the Auxiliary reference. The stored complex cable impedance will automatically be subtracted, on a complex basis, from all subsequent impedance measurements.

When using the Power-amp drive mode to measure impedance, you cannot use a reference measurement that was made in the Direct drive mode or visa versa. When switching drive modes, you must perform a fresh reference measurement through the Reference Go command. When multiple *RCAI* units are connected, you must also perform a fresh reference measurement if you change the driving *RCAI* unit. The Reference Go command automatically disconnects the load so this command can be executed at any time. The software will beep and warn you if you attempt to measure impedance using a reference not taken from the currently selected *RCAI* unit and with the currently selected drive mode.

Direct Impedance Measurement Procedure

Start *MLSSA* with setup file *IMP1K.SET*, *IMP20K.SET* or *IMP20KHR.SET* depending upon the frequency range and frequency resolution needed. You can also load one of these setup files through the Setup Load command. Execute Acquisition Interface Drive and select the Direct option

Connect your test leads to the phono jack labeled "SRC OUT" located on the rear panel of the *RCAI* in the area labeled "POWER AMPLIFIER". When using the SRC OUT connector for direct impedance measurements, keep in mind that the input impedance of your power amplifier is effectively in parallel with the test load impedance. If a power amplifier is currently connected and its input impedance is 10K ohm or higher, measurement errors will be negligible when measuring low impedance devices such as typical speaker drivers. However, if you are measuring higher impedance devices and/or the input impedance of your power amplifier is unusually low, it's best to temporarily unplug the TO IN connector that drives your power amplifier's input when making direct impedance measurements. Doing so avoids any possibility of direct impedance measurement errors due to your power amplifier's input impedance.

Connect the loudspeaker or other load to the test leads, which are connected to the SRC OUT connector located on the rear panel of the *RCAI*. Execute the Go Once command to measure and display its impedance.

For higher accuracy impedance measurements, you can optionally correct for the residual complex impedance of your test leads as follows: Short together the ends of your test leads and execute Go Once followed by Reference Auxiliary Store. The residual impedance of your test leads is now stored as the Auxiliary reference. The stored complex test lead impedance will automatically be subtracted, on a complex basis, from all subsequent impedance measurements.

Note that when using the Direct drive mode to measure impedance, you cannot use a reference measurement that was made in the Power-amp drive mode or visa versa. When switching drive modes, you must perform a fresh reference measurement through the Reference Go command. When multiple *RCAI* units are connected, you

must also perform a fresh reference measurement if you change the driving *RCAI* unit. The Reference Go command instructs the *RCAI* to temporarily disconnect whatever load is currently connected to the SRC OUT connector, which means that this command can be executed at any time. The software will beep and warn you if you attempt to use a reference not taken from the currently selected *RCAI* unit and with the currently selected drive mode.

Sensitivity / Impedance Measurement Procedure

This section explains how to use the *RCAI* to alternately measure the frequency response sensitivity of your loudspeaker or its impedance without swapping cables or changing the *MLSSA* setup. Note that details concerning how to window out room reflections in order to measure the anechoic frequency response or anechoic sensitivity of loudspeakers are not discussed in this section. Refer to the Applications section of the *MLSSA Reference Manual* for details regarding anechoic loudspeaker measurements in typical rooms as well as how to perform near-field measurements.

Start *MLSSA* with setup file LOUDS-Z.SET or, load this setup file through the Setup Load command. Execute Acquisition Interface Drive and select the Power-amp drive option. Execute FFT Bypass followed by Reference Go. *MLSSA* will measure the transfer function of your power amplifier and store it as the Main reference.

Connect the loudspeaker to the '+' and '-' banana jacks located on the front panel of the *RCAI*. Execute the Go Impedance command to measure the impedance of the loudspeaker. Execute the Overlay Store command to store it as an overlay.

For higher accuracy impedance measurements, you can optionally correct for the complex residual impedance of your speaker cables as follows: Short together the ends of the speaker cables that run from the *RCAI* to the loudspeaker. With the speaker-cable ends shorted together, execute Go Impedance followed by Reference Auxiliary Store. (Note: Be careful *not* to execute Go Once or else you may blow the internal 10-amp relay protection fuse.) The residual impedance of your speaker cables is now stored as the Auxiliary reference. The stored complex cable impedance will automatically be subtracted, on a complex basis, from all subsequent impedance measurements.

Connect your measurement microphone to the A mic mux input of the *RCAI*. Position your measurement microphone a known distance from the loudspeaker to be measured. Execute the Library Microphones Define command and enter the microphone calibration and preamp gain data for your microphone as one of 16 possible microphone numbers. Execute Library Microphones Assign and enter A

followed by the microphone number you just defined. Type Esc to return to the frequency domain then execute Acquisition Interface Mic-mux and select the A mic mux input. See the previous section titled “Assigning Microphones to Mic Mux Inputs” for more information on defining and assigning microphone/preamps.

Type Exit to return to the time domain. Execute the FFT Mode Sensitivity command and enter the reference impedance (typically 8 ohms) followed by the measuring distance in meters. Execute the Go Once command to measure the impulse response of the loudspeaker. If you are measuring in a normal room, use the marker and cursor to select anechoic segment. See the Applications section of *the MLSSA Reference Manual* for details. Execute the FFT Execute command to calculate and display the loudspeaker’s sensitivity curve. Execute the Calculate Weighted-level B-weighted command to calculate the B-weighted loudspeaker sensitivity.

To display both loudspeaker sensitivity and impedance simultaneously, execute Overlay Vertical-scale and select the Auto option. Next, execute the Overlay Plot command. See section below titled “Vertical Display Options for Overlays” for more information.

To repeat the impedance measurement, simply execute Go Impedance followed by Overlay Store. To repeat the sensitivity measurement, execute Go Once. Execute Overlay Plot to display both measurements.

Note that whenever the Go Impedance command is executed, *MLSSA* automatically but temporarily selects a rectangular time window that includes all of the available impulse response. After the Go Impedance command is completed, the time window length and shape revert back to whatever they were set to prior to executing the Go Impedance command. Therefore, the next time you execute Go Once, the time window you previously defined using the marker and cursor in the time domain will be again be applied in order to exclude room reflections when measuring loudspeaker frequency response and/or sensitivity.

Note that when using a power amplifier to measure impedance, the precision, internal 75-ohm, 10-watt power resistor is in series with the load. This resistor can overheat

when measuring impedance at high power levels over extended periods. If the rear panel temperature rises above 85° C, a thermal protection sensor will break the connection to the load. It may require several minutes for this thermal sensor to reset itself as the rear panel cools down below 70° C. During this reset period, you will not be able to perform impedance measurements or loopback reference measurements.

Note that when using the Power-amp drive mode to measure impedance or sensitivity, you cannot use a reference measurement that was made in the Direct drive mode or, one made using another *RCAI*, if more than one *RCAI* is connected. When switching drive modes or *RCAI* units, you must perform a fresh reference measurement through the Reference Go command. The Reference Go command automatically disconnects the load so this command can be executed at any time. The software will beep and warn you if you attempt to measure impedance or sensitivity using a reference not taken from the currently selected *RCAI* unit and with the currently selected drive mode.

Spatial Average Measurement Procedure

In the frequency domain, the Go Spatial-average command automatically steps through each connected microphone/preamp, in turn, starting with the currently selected mic mux input. This feature eliminates the need to manually re-position a single microphone to perform spatially averaged room or loudspeaker measurements. Up to 16 microphones can be multiplexed by connecting up to four *RCAI* units. The Go Spatial-average command still supports manual microphone positioning, if desired. You disable or enable automatic microphone positioning through the Acquisition Interface Options Spatial-averaging command. When the Manual option is selected, the currently selected *RCAI* mic mux input does not change during the Go Spatial-average command. Instead, you change the microphone position manually. Selecting the Auto option enables automatic microphone positioning using the *RCAI*.

Be aware that all inputs are initially assigned a microphone number of zero (0) meaning that the Go Spatial-average command's automatic input sequencing feature will not work until you define and assign all the microphones you intend to use. Refer to the previous section titled "Assigning Microphones to Mic Mux Inputs" for details on how to enter your microphone sensitivity and preamp gain data into *MLSSA* and also how to assign each microphone/preamp combination to one of the MIC MUX inputs located on the front panel of the *RCAI*.

The Library Microphones screen displays microphone calibration data for up to 16 microphones numbered 1 through 16. Assigning a microphone number of zero (0) to a particular mic mux input indicates that no microphone is connected to it. If a microphone number of zero is assigned to a mic mux input, that input will automatically be skipped during the Go Spatial-average command. For example, suppose you are using just 3 microphones connected to inputs A, B and C and that you have defined and assigned a microphone number to inputs A, B and C but not to input D, which should have an assigned microphone number of zero (0). Assume that you had previously selected mic mux input B through the Acquisition Interface Mic-mux command. Executing the Go Spatial-average command and entering six microphone positions to measure and average will result in the following sequence of measurements: B C A B C A. Note that the D input is never selected because it has a microphone number of zero

assigned to it. When Go Spatial-average command is completed, the selected mic mux input will return to B, where you started.

With more than one *RCAI* connected, the Go Spatial-average command can average up to 16 mic mux inputs using four daisy-chained *RCAI* units. First, you need to execute the Acquisition Interface Options Mic-mux-mode command and select the Global mic mux mode. Thereafter, the Go Spatial-average command will utilize all mic mux inputs that have a non-zero microphone/preamp assignment. See the next section titled “Controlling Multiple *RCAI* Units” for more information.

Controlling Multiple RCAI Units

With more than one *RCAI* connected, the Acquisition Interface Drive command asks which *RCAI* unit will actively drive a loudspeaker or other load. The other unit or units are disconnected from their respective loads and their source selection is set to Mute to turn off the drive signal to their respective power amplifiers.

With more than one *RCAI* connected, the mic mux selection can be made in either the Local or Global Mic-mux-mode as controlled by the Acquisition Interface Options Mic-mux-mode command. In the Local mode, there is no need to specify which *RCAI* unit is to be used for the mic input since it is assumed to be the current driving *RCAI*, as selected through the Acquisition Interface Drive command. The Local mode is handy if you have one *RCAI* in the lab near your computer and a second *RCAI* in an anechoic chamber. You switch from making measurements in the lab to the chamber using the Acquisition Interface Drive command. Thereafter, microphones are also automatically selected from those in the chamber whenever you execute the Acquisition Interface Mic-mux command or use the Go Spatial-average command. For example, if you execute Acquisition Interface Mic-mux and enter B, the mic mux input you just selected would be the B input on the driving *RCAI*, as previously determined when you executed the Acquisition Interface Drive command.

In the Global Mic-mux-mode, you can select any mic mux input regardless of the driving *RCAI* by first specifying the *RCAI* unit number, followed by the input letter. For example, executing Acquisition Interface Mic-mux and entering 3B means that you want the B mic mux input from the third *RCAI* in the daisy chain. Note that the unit number of a particular *RCAI* is determined by its order in the daisy chain. The unit connected directly to *MLSSA* is unit number 1; the next unit is number 2 etc. Thus, in Global mode you can select any one of up to 16 inputs independently of the driving *RCAI*.

In the Global Mic-mux-mode with two or more *RCAI* units connected, the Go Spatial-average command behaves differently. The mic mux input sequence will cross from one *RCAI* unit to the next higher unit in the daisy chain and finally return to the first unit until all inputs having a non-zero microphone number are used up. The entire sequence will be repeated, if necessary, until all measurements are completed. When

in the Local Mic-mux-mode, the Go Spatial-average command selects only those microphones connected to the driving *RCAI* unit.

Vertical Scaling Options for Overlays

The vertical scale and units for overlays need not match the vertical scale and units of the main trace. For example, an impedance curve can be overlaid on top of a frequency response curve and both can be clearly seen simultaneously. The type of vertical scale for plotting overlays is controlled by the Overlay Vertical-scale command, which is available in both the time and frequency domains. There are three options: Normal, Auto and Fixed. The Normal option causes overlays to be plotted with same vertical scale as the main trace. The Auto option causes overlays to be autoscaled. In this case, the possibly different vertical scale for the overlay data is drawn just below the vertical scale for the main trace data. There are thus two vertical scales shown on the screen simultaneously as shown in the example below. In addition, a description of the overlay data is displayed in the lower-left inside corner of the graphics area. The units of the overlay data need not match the units for the main trace. The Fixed option allows you to enter your own arbitrary vertical scale for the overlay data.



If an impedance curve is overlaid on top of a frequency response or other curve displayed in decibels, the impedance magnitude is displayed in units of ohms, not dB ohms. This makes it easy to display and print a loudspeaker's frequency response curve simultaneously with its impedance curve. An example is shown in the figure above.

Signals Available on the TURNTABLE / EXPAND Connector

The TURNTABLE / EXPAND DB-9 connector located on the front panel of the *RCAI* either buffers or passes through most of the digital signals available on J4 of the *MLSSA 2000* card. Note the following exceptions.

1. The *RCAI* normally buffers the clock signal originating on J4 pin 3 of the *MLSSA* card. The buffered version is output on pin 3 of the TURNTABLE / EXPAND connector. This is normally preferable because the buffered clock can drive much longer cable runs as compared to the original clock. However, buffering the clock does not allow an external clock to be supplied to *MLSSA* through the TURNTABLE / EXPAND connector of the *RCAI*. If you wish to supply an external clock to the *MLSSA* card with an *RCAI* connected, you must first disable the buffering. Remove the two screws located in the bottom cover of the *RCAI* and remove the top cover. Locate the three jumper pins labeled JP1. Remove the jumper shunting JP1 pins 2 and 3. Re-install the same jumper onto JP1 pins 1 and 2. You can now supply an external clock to *MLSSA* through pin 3 of the TURNTABLE / EXPAND connector. The clock source must be capable of driving the entire length of cable connecting the *RCAI* to the *MLSSA* card. Note that when two or more *RCAI*s are daisy chained together; each *RCAI* unit in the daisy chain must have its JP1 pins 1 and 2 shunted together.
2. The MLS digital signal output on J4 pin 7 of the *MLSSA* card is not available on the TURNTABLE / EXPAND connector of the *RCAI*. This signal is stopped at the source by the modified DB-9-to-DB-9 cable supplied with your *RCAI*. The supplied cable has pin 7 removed from the male DB-9 end which plugs into J4 on the *MLSSA* card. Removing pin 7 is intentional since long cables can load down this signal creating skew in its timing which can lead to lowered accuracy of MLS measurements. In particular, the skew due to capacitive loading can result in the appearance of small spurious spikes in the tail of the measured impulse response. Therefore, you should not substitute another DB-9 cable for the one supplied with your unit for the digital connection to your *MLSSA* card. You can however extend the cable length by daisy chaining a standard DB-9-to-DB-9 extension cable to the one supplied with

your *RCAI* as long as the supplied cable is the one connected directly to J4 on your *MLSSA* card.

The following table summarizes all the signals available on the TURNTABLE/EXPAND connector. Note that all are TTL compatible and all inputs are pulled up to +5 volts using 4.7 k ohm resistors. You should never attempt to apply any analog signal to any of these pins.

For static discharge protection, all used inputs and outputs should be shunted by a 5.1-volt zener diode to digital ground on pin 4 of the TURNTABLE / EXPAND connector. Connect the zener's anode to digital ground and its cathode to the TTL input or output line as required, preferably as close to the connector as possible. This arrangement serves to clamp any stray voltage between -0.6 and +5.1 volts to prevent damage caused by static discharge.

<i>Pin number</i>	<i>Digital Signal</i>
pin 1	+12 volts DC power for the <i>RCAI</i> (output)
pin 2	Macro Command Signal 10 ms pulse (output)
pin 3	Sample rate clock (output or input) (see paragraph 1 above)
pin 4	Digital ground
pin 5	Macro Command Wait sense line (input)
pin 6	External acquisition trigger (input)
pin 7	Not connected (see paragraph 2 above)
pin 8	External time base clock (input)
pin 9	Internal trigger not delayed (output)

The following is a detailed description of each digital signal available through J4.

1. This pin is +12 volts DC.
2. Macro Command Signal pulse. A positive-going TTL pulse of 10 ms duration is output on this line when executing the Macro Command Signal during macro execution.

3. Sample rate clock. This TTL level signal acts as either an input or an output as controlled by software. Normally, pin 3 supplies the internally generated sample rate clock to an external device. The internal clock generator can be disabled through the Acquisition Clock External command, which places this pin into a high impedance state allowing an external sample rate clock signal to be applied. The external sample rate clock source must supply a negative-going TTL pulse having a pulse width between 250 nanoseconds and 1 microsecond. Longer or shorter pulse widths will result in a malfunction of the data acquisition hardware. The leading or negative-going edge of this signal is the active edge.
4. Digital ground. Digital ground reference for all external digital connections. This pin should be connected to ground on the device being interfaced to the *RCAI*. Note that this pin should not be connected to analog ground of any external analog device.
5. Macro Command Wait sense line. This Schmitt-triggered TTL input allows an external positive going pulse to be sensed by the Macro Command Wait command during macro execution. You can connect a push-button switch between this pin and pin-4 (digital ground). Then, you momentarily press this switch to enable the macro to continue. For static discharge protection, you should also connect a 5.1-volt zener diode across this switch. Connect the zener's anode to digital ground and its cathode to the TTL input side.
6. External trigger. This Schmitt-triggered TTL input allows an external event to trigger a data acquisition sequence. This feature is selected by the Acquisition Trigger Select Plus (for an external positive-going edge trigger) or Acquisition Trigger Select Minus (for an external negative-going edge trigger) commands.
7. Not Used.
8. External time base clock input. Not supported by the *MLSSA* software at this time.
9. Internal trigger output. This TTL output is the internally generated acquisition trigger. When the MLS generator is enabled, it is a positive-going pulse having a pulse width equal to the period of the sample rate clock.

