Model AA-51A Audio Analyzer

User's Guide

June 2000

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1 General Description

1.1 Overview

The AA-51A is a multi-purpose, precision audio analyzer, that helps to automate broadcast station proof-of-performance measurements and equipment maintenance. It is designed to work efficiently with the companion AG-51 Audio Generator, especially for Intermodulation Distortion, Total Harmonic Distortion, and stereo broadcast system measurements. Having the generator and analyzer in two separate assemblies allows local measurements, as well as complete measurement capabiltities through one-way links, such as from a studio to a remote transmitter. The AA-51A analyzer measures:

- **Audio Voltage.** The AA-51A voltmeter can be used for general purpose voltage, gain, and frequency response measurements. The meter is calibrated in voltage, dB, and dBm referenced to 600 Ohms. It has a flat frequency response (±0.1 dB) range of 20 Hz to 200 kHz, and eleven full-scale voltage ranges from 0.3 mV (-68 dBm) to 30 V (+32 dBm). The average responding meter is calibrated to the rms value of a sinewave.
- **Total Harmonic Distortion (THD).** Total harmonic distortion levels are automatically measured in six full-scale ranges of 0.03% to 10% for any fundamental frequency from 20 Hz to 20 kHz. Harmonics to 100 kHz are measured. It automatically accomplishes nulling, tuning, and leveling to the input frequency for signals between 0.1 and 80 Vrms.
- **Intermodulation Distortion (IMD).** Intermodulation distortion levels are automatically measured in six full-scale ranges of 0.03% to 10% in accordance with the SMPTE Standard, using a 60 Hz and a 7 kHz signal in a 4:1 voltage ratio. Measurements are completely automatic over a wide dynamic range. A high precision IMD signal, with the SMPTE characteristics, is available directly from the companion AG-51 Audio Generator.
- **[Signal + Noise] / [Noise].** Noise levels as low as -85 dBm (600 Ohms) can be measured. The noise measuring function is essentially the same as the audio voltmeter function described above, except that the operating passband is restricted to a 3 dB bandwidth of 20 Hz to 20 kHz.
- **Stereo Phase.** The relative phase angle between two signals is measured in two ranges of ±54 degrees and ±180 degrees, within a frequency range of 20 Hz to 20 kHz. Phase angle is displayed with a zero-center scale indication. The companion AG-51 Audio Generator provides precision 0 degree (L+R) and 180 degree (L-R) test signals.
- **Stereo Ratio.** The amplitude ratio of two signals is measured over a range of ±6 dB within the frequency range of 20 Hz to 20 kHz. The ratio meter indication is a zero-center scale with ±6 dB full-scale deflection.
- **Wow and Flutter.** Incidental frequency modulation ("Wow and Flutter") usually associated with tape decks, cartridge machines, and turntables is measured automatically in two full-scale ranges of 0.3% and 0.1%. The AA-51A measures weighted peak flutter as specified by IEEE Standard 193 using a 3.15 kHz (± 10%) at a level between 0.1 Vrms and 80 Vrms. The companion AG-51 Audio Generator provides a highly stable 3.15 kHz test signal.
- **Frequency.** The AA-51A includes a fast response four-digit LED display of input frequency. The decimal point and Hz/kHz indicators shift automatically to maintain optimum resolution. The counter functions in all AA-51A operating modes.

1.2 AA-51A Audio Analyzer Key Features

- **Auto-Null Total Harmonic Distortion Measurement**
- **Switch selectable 400 Hz high pass input filter to reduce line frequency noise**
- **Switch selectable 22 kHz low pass filter to allow THD measurement of digital signal sources**
- **Oscilloscope and headphone monitor outputs**
- **LED indicators for out-of-range input levels**
- **Uncalibrated meter adjustment mode for easy relative measurements**
- **Digital frequency readout**
- **Compatibility with NAB Test CD's***
- **Shielded and balanced inputs**
- **Extensive RFI shielding for operation in high power transmitter signal environments**
- **Rugged protective carrying case with handle**
- **Auxiliary AC power outlet on rear panel for powering companion test equipment**

*See Section 3.3.6 on page 16 for information regarding NAB Compact Discs

1.3 Specifications

1.3.1 Inputs

Impedance	Balanced 80 k Ohms, plus 100 pF, each pin to ground
Maximum AC	220 Vrms, each pin to ground
Maximum DC	250 Vdc, each pin to ground
Common-mode rejection	greater than 60dB
Cable connector	Switchcraft p/n 05CL3M
MON SCOPE output	5.6 V pk-pk for inputs from 40 mVrms to 90 Vrms, typical
MON PHONES output	Adjustable to 70 mVrms with rear panel control.
HIGH LED on when	Input greater than 80 Vrms (not active in VM and NOISE modes)
LOW LED on when	Input less than 100 mVrms, (not active in VM and NOISE modes)

1.3.2 AC Voltmeter (VM)

Frequency response	10 Hz to 100 kHz, ±0.1dB max. variation
Ranges	11 ranges, 0.3 mV to 30 V full scale, -68 dBm to +32 dBm full scale
Accuracy	±3%
METER MON output	100 mV pk-pk, meter at full scale
Internal noise	20 uV (-92 dBm) maximum
Filter	400 Hz (at -3 dB) high-pass, switch selected
REF SET Range	greater than 10 dB

1.3.3 Total Harmonic Distortion Meter (THD)

Input frequency range	20 Hz to 20 kHz, fundamental
Measurement passband	1.7x to 12.5x input frequency at -3dB
Notch attenuation	greater than 100 dB
Ranges	6 ranges, 0.03% to 10% full scale, -20 dB to -70 dB full scale
Accuracy	±15% (±1.5 dB)
Input level range	100 mV to 80 Vrms
Internal THD + noise	0.01% max, 0.006% typical, 20 Hz-5 kHz 0.02% max, 0.012% typical at 20 kHz
Filters	22 kHz low-pass at input, switch selected 400 Hz high-pass, switch selected
METER MON output	100 mV pk-pk, meter at full scale
Nulling time	2 seconds approximately

1.3.4 Intermodulation Distortion Meter (IMD)

Input signal required	60 Hz + 7 kHz, 4:1 voltage ratio
Full scale ranges	6 ranges, 0.03% to 10% full scale
Accuracy	±10%
Input level range	100 mV to 80 Vrms
Internal IMD + noise	less than 0.015%
METER MON output	100 mV pk-pk, meter at full scale

1.3.5 Noise Meter (NOISE)

Frequency response	20 Hz to 20 kHz at -3 dB
Ranges	11 ranges, 0.3 mV to 30 V full scale
Accuracy	±3%
METER MON output	100 mV pk-pk, meter at full scale
Internal noise	15 uV (-94 dBm) max.
Filter	400 Hz (at -3 dB) high-pass, switch selected
REF SET range	greater than 10 dB

1.3.6 Phase Meter (PHASE)

Measurement ranges	
x3	±54 degrees full-scale
x10	±180 degrees full-scale
Accuracy	±3 degrees
Polarity	Positive angle means Left leads Right input
Input frequency range	20 Hz to 20 kHz
Input level range	100 mV to 80 Vrms
METER MON output	The input signal is converted to a rectangular wave at the input frequency. The duty cycle of the rectangular signal is proportional to the phase angle.

1.3.7 Ratio Meter (RATIO)

Measurement range	±6 dB
Accuracy	±0.2 dB
Polarity	Positive ratio means R greater than L
Input frequency range	20 Hz to 20 kHz
Input level range	100 mV to 80 Vrms
METER MON output	DC voltage proportional to ratio

1.3.8 Wow & Flutter Meter (%W&F)

Measurement ranges	0.1% and 0.3% full scale
Input frequency	3.15 kHz, ±10%
Accuracy	±10%
Input level range	100 mV to 80 Vrms
Internal noise	less than 0.01%
METER MON output	500 mV pk-pk at full scale, passband 0.2 Hz - 200 Hz

1.3.9 Frequency Counter

Frequency range	10 Hz to 200 kHz
Resolution	less than 900 Hz (approx.), 0.1 Hz
	900 Hz to 9000 Hz (approx.), 1.0 Hz
	9 kHz to 24 kHz (approx.), 0.01 kHz
	greater than 24 kHz (approx.), 0.1 kHz
Accuracy	-1 to 0 count error in RH digit (LSD)
Input level range	1 mV to 80V

1.3.10 Auxiliary AC Output

Current	4.0 Amperes rms, maximum

1.3.11 Power

Voltage	117 VAC (230 VAC option), 50/60 Hz
Power Consumption	10 Watts

1.3.12 Weight

Pounds	12
Kilograms	5.44

1.3.13 Dimensions

Inches **(W x H x D)**	15.25 x 5.25 x 10.125
CM **(W x H x D)**	38.74 x 13.34 x 25.72
Optional Rack Mount	3-ru required (5.25 inches, or 13.34 cm)

Specifications subject to change without notice.

2 Installation

2.1 Unpacking

The AA-51A is packed in a custom shipping carton. Inspect the carton for any signs of serious damage. Report any damage to the shipping company.

Carefully remove the AA-51A from the shipping carton. A technical manual and power cord are also included in the carton. It is recommended that the carton and packing materials be stored in case that the unit must be shipped.

The AA-51A is ready for operation as delivered. It only requires an AC power source. To operate the unit, remove the front protective cover which is is held on with four snap-release holders.

WARNING

The AA-51A must be used with a 3-prong grounded receptacle outlet. Failure to use a grounded outlet may result in improper operation or a safety hazard.

2.2 Reshipment to Factory

If at all possible, the unit should be shipped in its original carton if it must be returned to the factory. Shipping cartons can be ordered from the factory if other suitable packaging is not readily available. Contact information can be found in Section 5 on page 24 of this manual.

If the AA-51A fails to perform properly, initially or after a period of use, it is advisable to contact a factory technician. If repair is required, an RMA number must first be obtained from the factory. For returned units that are not under warranty, repair cost estimates will be provided. Authorization to proceed must be obtained from the customer before repairs will be completed. If return to the factory is not possible, Potomac Instruments can supply technical data and parts. Please contact the factory for a cost estimate.

Note

A **Return Material Authorization** (RMA) number must be obtained prior to returning a unit to the factory. A copy of a Return Material Authorization form is included as Appendix A to this manual. Please call, fax, or e-mail the factory to obtain an RMA number. Please also fax a copy of the RMA to the factory and include a copy of the RMA in the carton with the unit. Contact information can be found in Section 5 on page 24 of this manual.

2.3 Warranty for Equipment and Accessories

Potomac Instruments, Inc., warrants each new equipment to be free of defects in material and workmanship, for a period of one (1) year after the date of original shipment, except for fuses, transistors, diodes, and integrated circuits, which are warranted for a period of ninety (90) days. Any instrument which is found within one year not to meet the foregoing standards after examination by our factory, will be repaired, or at the option of Potomac Instruments, replaced without charge. This warranty does not apply to equipment which has been altered, improperly handled, or damaged in any way.

3 Controls and Indicators

3.1 Front Panel

Refer to Figure 1 for the following discussion. The numbers shown in parentheses ( ) are used as identifiers in the discussion below.

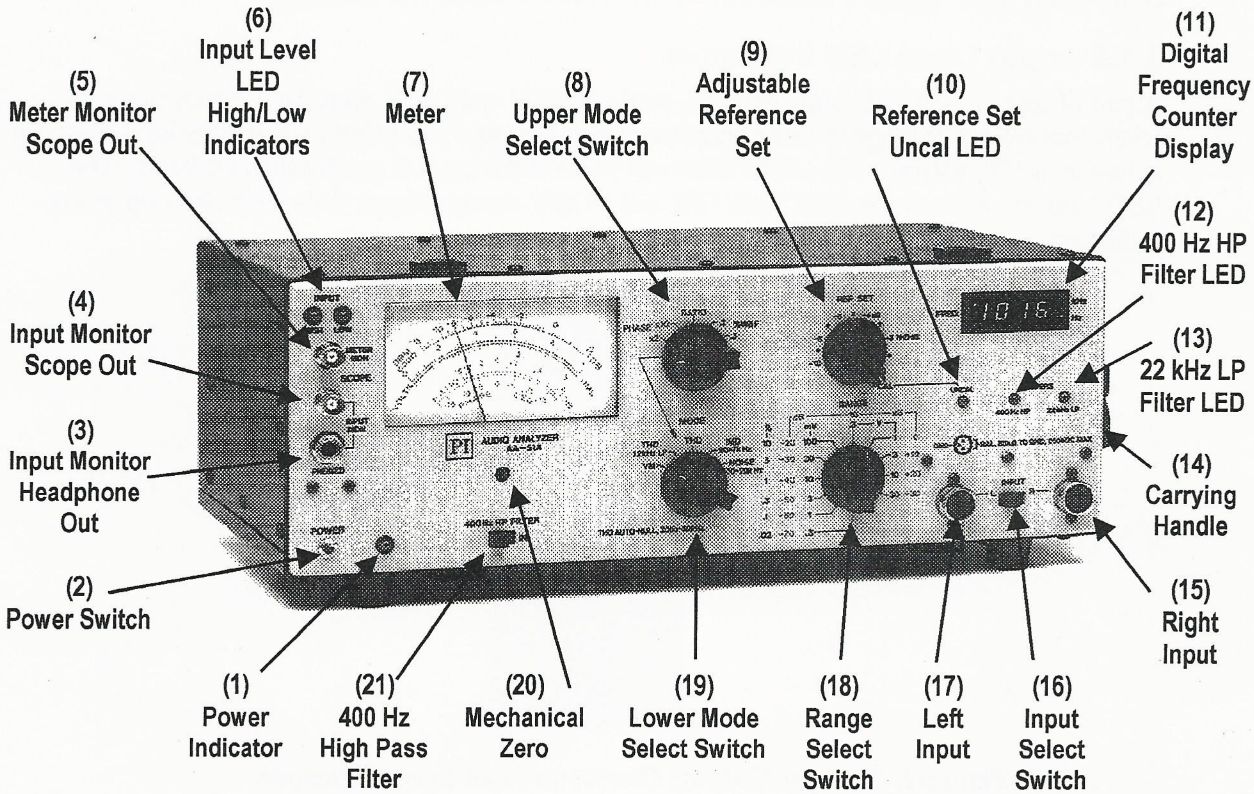

Figure 1. AA-51A Front Panel Controls, Connectors, and Indicators

3.1.1 Power Switch and Indicator

The AC Power Switch (2) is located in the lower left corner of the front panel. Placing the toggle switch in the upper position applies power to the unit. An LED Power Indicator (1), just to the right of the switch, will be illuminated when the unit is operating.

3.1.2 Input Monitor Headphone Output

The Input Monitor Headphone Output (3) permits listening to the signal that is applied to the selected input connector before it passes through any filters or nulling circuitry. A headphone gain control is located on the rear panel to adjust the level at the headphones. High or low impedance headphones with a standard "tip-sleeve" or "tip-ring-sleeve" headphone plug can be used. Figure 2, on page 8, shows a close-up of the connector and markings.

3.1.3 Input Monitor Scope Output

The Input Monitor Scope Output (4) permits oscilloscope monitoring of the signal that is applied to the selected input connector before it passes through any filters or nulling circuitry. A BNC connector is used. Figure 2 shows a close-up of the connector and markings.

3.1.4 Meter Monitor Scope Output

The Meter Monitor Scope Output (5) permits monitoring the signal that drives the meter. The signal at this output will have passed through any selected filters or nulling circuitry. A BNC connector is used. Figure 2 shows a close-up of the connector and markings.

3.1.5 Input Level LED Indicators

A pair of Input Level LED Indicators (6), marked HIGH and LOW, alert the operator to signal levels that are out of range to make accurate measurements. The LOW LED will be on if the input is less than 100 mVrms. The HIGH LED will be on if the input is greater than 80 Vrms. The LED's are not active in the VOLTMETER and NOISE modes. Figure 2 shows a close-up of the indicators.

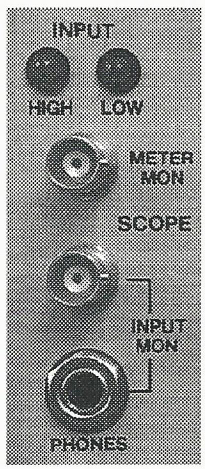

Figure 2. Monitor Outputs Connectors and Level Indicators

3.1.6 Meter and Mechanical Zero

The Meter (7) has five scales. The uppermost scale is calibrated in dBm referenced to 600 ohms. It corresponds to the green markings associated with the Range Select Switch. The two middle scales are linearly calibrated for measuring voltage and percentages of distortion. They correspond to the black markings associated with the Range Select Switch for Volts, mV, and % of distortion, and with the Upper Mode Switch for percent of Wow and Flutter. The bottom two scales are used with the Upper Mode Switch for RATIO and PHASE measurements. When used in the RATIO mode, the upper scale is used directly in dB. When in the PHASE mode the lower scale corresponds to the PHASE x3 Mode for readings up to ±54 degrees (±15 equals ±45 degrees). In the PHASE x10 Mode the lower scale corresponds for readings up to ±180 degrees (±15 equals ±150 degrees).

The meter's Mechanical Zero (20) adjustment is accessible through a hole in the front panel just below the meter face. Before operating the AA-51A for the first time, check the meter mechanical zero. To do this, if the analyzer is on, turn it off, and allow 2 to 3 minutes for complete capacitor discharge. Turn the meter zero adjust screw, shown below, using a small-bladed screwdriver until an exact zero indication is achieved.

Figure 3 shows a close-up of the meter face and the mechanical zero adjustment.

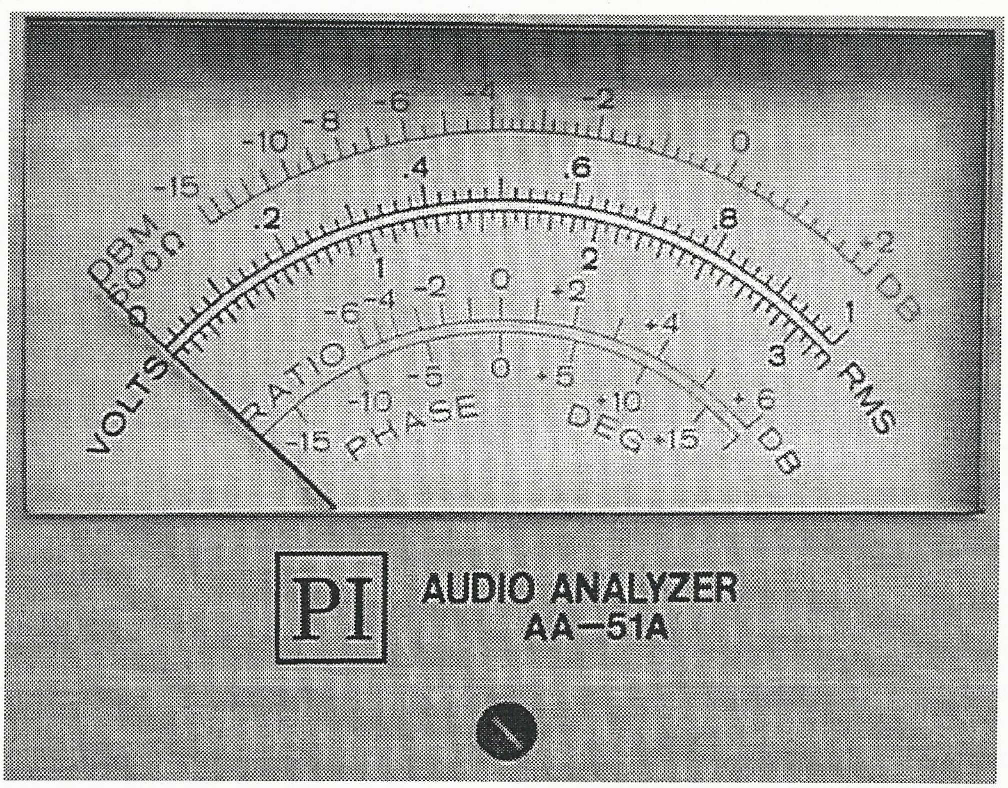

Figure 3. Meter Face Close-up View

3.1.7 Upper and Lower Mode Select Switches

Refer to Figure 4 for the following discussion.

The Upper Mode Select Switch (8) is used to select the PHASE x3, PHASE x10, RATIO, 0.1% W&F (Wow and Flutter), and the 0.3% W&F. In its most counter-clockwise position the switch transfers control to the Lower Mode Select Switch.

The Lower Mode Select Switch (9) is used to select the VM (Voltmeter), THD 22 kHz (Total Harmonic Distortion below 22 kHz), THD (Total Harmonic Distortion), IMD (Intermodulation Distortion), and the NOISE functions. The Upper Mode Select switch must be in its most counter-clockwise position for this switch to be functional.

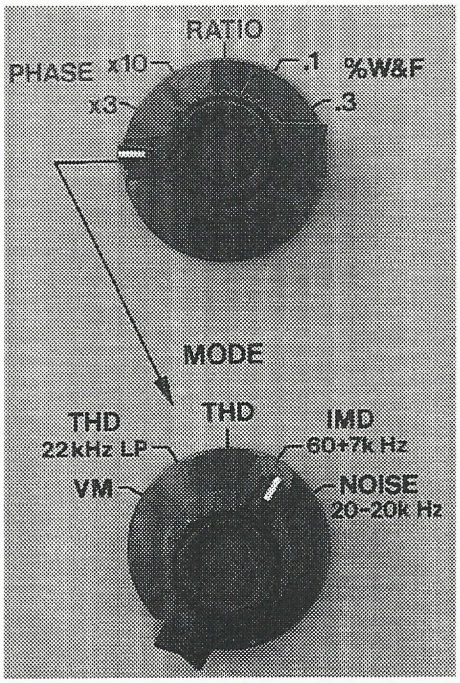

Figure 4. Mode Select Switch Close-up View

3.1.8 Range Select Switch

The Range Select Switch (18) is used to select the full scale range in Volts, dB, and Percentage.

The black innermost markings are associated with the Meter's center black ranges. They range from full-scale readings of 0.3 milliVolts rms (mVrms) to 30 Volts rms (Vrms). They are used with the Voltmeter (VM) and NOISE measurement modes.

The next set of markings, in green, is associated with the Meter's uppermost scale, which is also green. The scales range -70 dB to +30 dB. The readings are direct in dBm when measuring 600 Ohm sources (0 dBm = 1 mW across 600 Ohms). These scales are also used with the Voltmeter (VM) and NOISE measurement modes.

The left-most black markings are in PERCENT, and they too are associated with the Meter's center black ranges. They range from full-scale readings of 0.03% to 10% and are used in conjunction with the Total Harmonic Distortion (THD) and the Intermodulation Distortion (IMD) measurement modes. Readings above the 10% marking are essentially non-functional and irrelevant.

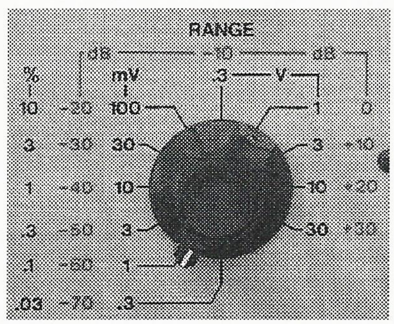

Figure 5. Range Select Switch Close-up View

3.1.9 Adjustable Reference Set Control and UNCAL LED

The Adjustable Reference Set Control (9) allows uncalibrated meter readings, such as for making relative power measurements. The meter readings are calibrated when this control is in its most clockwise and locked position. Turning the control counter-clockwise provides up to 10 dB of continuously variable meter adjustment range. When the control is in the unlocked, or uncalibrated position, the UNCAL LED (10) will be illuminated. Refer to Section 4.2.2 on page 19 for an explanation of the THD dB function. Figure 6 shows a close-up of the control and LED.

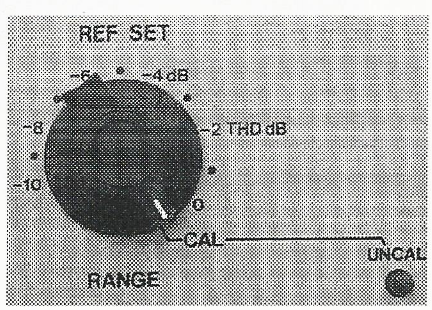

Figure 6. Adjustable Reference Set Control and UNCAL LED Close-up View

3.1.10 Digital Frequency Counter

A four-digit LED Frequency Counter Display (11) indicates the frequency of the input signal. The frequency counter is auto ranging, i.e., it automatically sets the decimal point, and an additional indicator shows whether it is measuring Hz or kHz. Figure 7 shows a close-up view of the display.

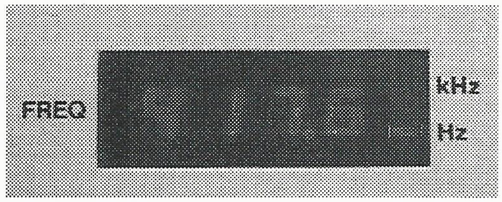

Figure 7. Frequency Counter Close-up View

3.1.11 400 Hz HP Filter Select Switch and LED

The 400 Hz HP (21) filter select switch is located below the meter. The Input signal passes through a 400 Hz High Pass filter when this switch is in the "IN" position. The 400 Hz HP LED (12), located below the Frequency Counter display, lights when the filter is selected.

3.1.12 22 kHz LP Filter LED

The 22 kHz LP Filter LED (13) lights when the THD 22 kHz LP mode is selected with the Lower Mode Switch. The LED is located below the Frequency Counter display.

3.1.13 Left and Right Signal Inputs and Input Select Switch

The Left (17) and Right (18) Signal inputs are located in the lower right corner of the front panel. They are used to apply signals to the analyzer for measurement. The PHASE and RATIO modes use both connectors simultaneously. The other modes use one or the other input, as selected by the Input Select Switch. The mating connectors are Switchcraft Part Number O5CL3M, available from Switchcraft distributors or from Potomac Instruments.

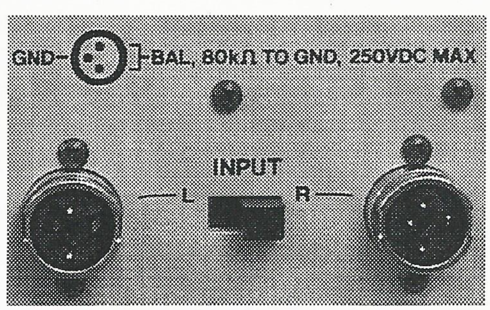

Figure 8. Left and Right Signal Inputs and Input Select Switch Close-up View

3.2 Rear Panel Controls and Connectors

Please refer to Figure 9 for the following discussion.

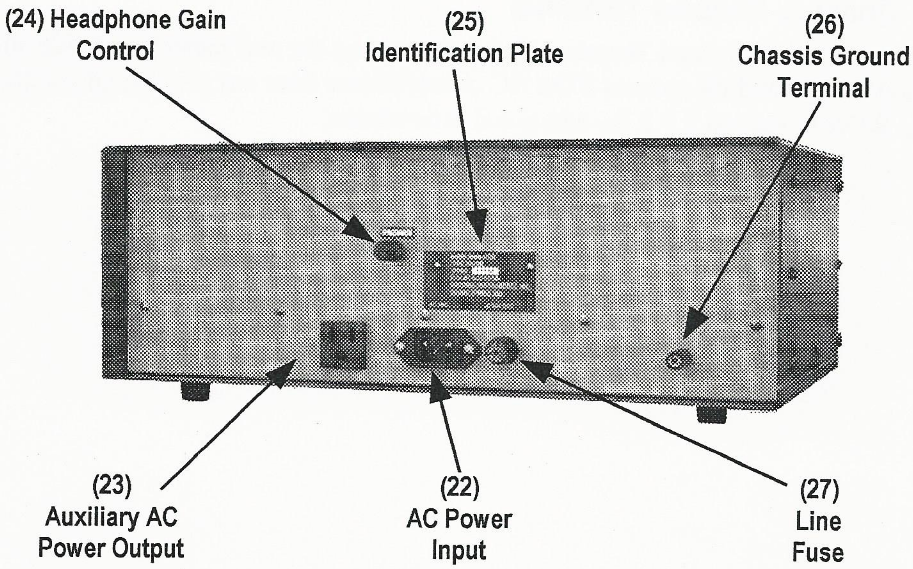

Figure 9. AA-51A Rear Panel Connectors and Controls

3.2.1 AC Power Input

A power cable with a standard IEC-type power connector provides AC Power Input (22)to the AA-51A. The units are available from the factory for either 115 or 230 VAC operation. The voltage requirements are listed on the Identification Plate described below.

3.2.2 Auxiliary AC Power Output

A North American style three-prong Auxiliary AC Power Output (23) connector provides an unfused AC outlet to power companion equipment such as the AG-51 Audio Generator or an oscilloscope. The maximum current which can be safely drawn from this connector is 4.0 Amperes rms.

3.2.3 Fuse Location

The AC Line Fuse (27) is accessible in a screw-type holder on the rear panel. A 3/16 ampere, 250 VAC slow-blow fuse is installed for units configured for 115 VAC operation. A 1/8 ampere, 250 VAC slow blow fuse is installed in units configured for 230 VAC operation. The operating voltage and fuse value is listed on the Identification Plate described below.

3.2.4 Headphone Gain Control

The level of the front panel Input Monitor Headphone Output is controlled by the Headphone Gain Control (24) located on the rear panel.

3.2.5 Identification Plate

The Identification Plate (25) shows the model number, serial number, AC Voltage requirements, and the fuse size and type.

3.2.6 Chassis Ground Terminal

A three-way Chassis Ground Terminal (26) is located on the rear panel to provide additional protection and grounding options if the AC power source does not provide an adequate earth ground. Refer to section 3.3.2 for additional information.

3.3 General Operating Information

3.3.1 Meter Mechanical Zero

Refer to Section 3.1.6 on page 19 for instructions on setting the Meter Mechanical Zero if the Meter does not read exactly zero when the unit is level and powered off.

3.3.2 AC Power

The AA-51A Audio Analyzer should be operated from a 115 or 230 volt AC power source according to the rating on the Identification plate located on the rear panel.

3.3.3 Grounding

When the AA-51A power cord is plugged in, the chassis is connected directly to the AC power neutral line through the third wire of the power cord. This may or may not provide minimum pickup of unwanted hum and noise in the measuring circuits. Often the AA-51A must be grounded solidly to the equipment under test to obtain minimum hum pickup. This connection may be made using the test cable shield, which is connected to the chassis, or by a separate wire from the ground binding post on the rear of the unit. In such cases, it may also be necessary to isolate chassis ground from power line ground, using a three-prong-to-two-prong adapter to obtain minimum noise pickup. If this is done, be certain to observe the following warning:

WARNING

> Be certain that the chassis of the AA-51 is solidly grounded to an earth-grounded point before using the unit. Dangerous voltage may be present on the AA-51A chassis if it is not adequately grounded. A separate ground connector is located on the rear panel, as described below.

3.3.4 Use of METER MONITOR OUTPUT

The METER MONITOR OUTPUT connector provides a 100 mV pk-to-pk output for full-scale meter deflection. The output is designed to monitor the meter signal with an oscilloscope. The combination of the analyzer and oscilloscope provides more significant information about the device under test than is expressed in a meter reading alone. The METER MONITOR output impedance is 2200 Ohms, and excessive loading should be avoided to maintain the accuracy of meter readings. High impedance oscilloscope inputs should have negligible effects on the readings. Refer to sections 3.1.3 and 3.1.4 for more information about the Oscilloscope outputs.

3.3.5 Equipment Performance Measurements

Equipment Performance Measurements (EPM), used to determine a broadcast facility's audio performance, are required by the Federal Communications Commission (FCC), and are described in various sections of the FCC Rules, Part 73. These tests are commonly referred to as an "Audio Proof" although the FCC prefers to use the term "Proof" only for measurements to verify the performance of AM directional antenna systems. Useful guides to these EPMs for AM and FM stations have been prepared by Broadcast Engineering Magazine, and are available from Broadcast Engineering, P.O. Box 12901, Overland Park, Kansas, 66212.

3.3.6 NAB Test CDs as Test Signal Sources

The NAB (National Association of Broadcasters) has issued Compact Discs (CDs) containing test signals. The CDs are designated "Broadcast and Audio System Test CD, Volume I and Volume II." Some of the signals on the CDs which are particularly useful with the AA-51A are listed below:

- **Fast full-band THD Test.** Vol. II, Track 28, has 12 frequencies, 32Hz to 16kHz, each on for 10 seconds. This provides adequate time for the AA-51A to give a THD reading at each frequency.
- **Full-band THD and Frequency Response Test.** Vol. I, Tracks 14 through 29, gives 16 frequencies, 20 Hz to 20 kHz, each on for 30 seconds.
- **THD Calibration.** Vol. I, Tracks 76,77,78, and 79 have 400 Hz tones with 800 Hz second harmonics of 0.1%, 0.3%, 1%, and 3%, each on for 30 seconds. The 0.1% THD signal gives a noticeably distorted second harmonic because of the limitations of digital sampling. Distortion is less as the percent of THD increases.
- **IMD Test Signal.** Vol. I, Track 30, provides an IMD test signal with 60 Hz and 7 kHz signals with amplitude ratios of 4:1 and 1:1. The residual distortion is somewhat high because of the limitations of digital sampling.
- **Wow and Flutter Test**. Vol. I, Track 72, provides a 3.15 kHz test signal, on for 30 seconds.
- **Wow and Flutter Calibration.** Vol. II, Tracks 14 and 15, on for 30 seconds each, have test signals for calibrating a DIN/IEEE flutter meter with peak flutter values of 0.1% and 0.3% sinusoidal flutter.

The NAB CDs are available from the NAB Bookstore, 1771 N Street, N. W., Washington, D. C. 20036, phone (202) 429-5300.

4 Operation

4.1 Voltmeter Mode

The AA-51A becomes a general purpose AC voltmeter when the **Lower Mode Select Switch** is set to the **VM** position.

NOTE

The **Upper Mode Selector Switch** must be in its most counter-clockwise position to for the **Lower Mode Select Switch** to be operational. Refer to Figure 4 on page 10 for a close-up photo of the Upper and Lower Mode Select switches.

4.1.1 Absolute Voltage Measurements

NOTE

Absolute Voltage Measurements provide readings of the actual voltage. The readings may be in Volts, milliVolts (mV) or in dBm referenced to 600 Ohms. The measurements are designed to display the rms voltage value of a sine wave.

a. Position the **Range Select Switch** to a range exceeding the value of the signal to be measured.
b. Connect a signal to either the **L** or **R Connector** with the **Input Select Switch** in the appropriate position.
c. Set the **Range Select Switch** to give a meter reading as close to full-scale as possible.
d. Observe the **Meter** indication and meter Range setting to obtain the signal level. The meter's green uppermost scale is calibrated in **dBm** referenced to 600 ohms. It corresponds to the green markings associated with the **Range Select Switch**. The two middle scales are linearly calibrated for measuring voltage. They correspond to the black markings associated with the **Range Select Switch** for **Volts, mV**. A close-up view of the meter is available on page 9.

4.1.2 Relative dB Voltage Measurements

NOTE

Relative dB voltage measurements are useful for performing frequency response or amplitude gain characteristics. Steps for performing relative measurements are listed directly below.

a. Follow steps A through C directly above, at the desired reference frequency, such as 1 kHz.
b. Adjust the **Reference Set** control so that the needle is at a convenient reference point, such as 0 dB, on the **Meter**. The difference in dB above or below the reference reading can now be read directly on the dB scale.

4.2 Total Harmonic Distortion (THD) Mode

Total harmonic distortion is a measured by applying a single frequency signal to the input of the analyzer. The analyzer then automatically eliminates the input signal by "nulling" or "notching" it out of the measurement spectrum with precision electronic filters. The remaining harmonics (multiples) of the input signal, and any associated noise, are then measured. The total power level of the harmonics and noise, with respect to the fundamental input signal, is expressed as a percentage of the total power measured for the fundamental plus the harmonics.

The THD filter, along with its rejection notch at the input frequency, has a passband from 1.7x to 12.5x the input frequency. For example, with an input frequency of 1.0 kHz, the meter sums frequency components between 1.7 kHz and 12.5 kHz. This includes harmonics from 2.0 kHz to 12.0 kHz and noise between 1.7 kHz and 12.5 kHz. All frequency components well below the filter notch, which in this case would inlcude power frequency components at mulitples of 60 Hz, are attenuated by approximately 14 dB. These power-frequency components would fall within the measurement passband for a measurement frequency near 30 Hz.

The AA-51A does not accurately read values above 10%, and the readings with the **Range Select Switch** at higher positions are invalid. If the THD is actually greater than 10%, the meter may be off-scale, or may read zero because of the action of the lock detector circuit.

4.2.1 Measuring Percentage of Total Harmonic Distortion

To measure percentage of Total Harmonic Distortion (THD), use the following steps:

a. Verify that the **Upper Mode Select Switch** is in its most counter-clockwise position. Set the **Lower Mode Select Switch** in the **THD** or **THD/22 kHz LPF** position. The 22 kHz filter is useful when the device under test has low-power, non-harmonic frequency components, in its output above 20 kHz. These components cause abnormally high THD readings at the higher audio frequencies. They are common in Compact Disk (CD) players and other digital sources.

b. Connect test leads from the device under test to the **L** or **R Input** connector and set the **Input Select Switch** appropriately to select the test signal.

c. Apply a low-distortion sine-wave test signal to the device under test at the desired level and frequency. Typical signal sources include the companion AG-51, or an NAB Test CD (see Section 3.3.6 on page 16 for information about the NAB Test CD).

d. With the device under test operating, see that the **Input Level High** and **Low LED** indicators are both OFF, indicating that the input level is within the range for accurate readings.

e. One to two seconds after the signal is connected, the **Frequency Counter** should display the signal frequency. In another one to two seconds, the meter should display the THD reading.

f. Adjust the Range Select Switch for an upscale reading, using only the % positions to the left of the knob (refer to Figure 5 on page 11 for a close-up view of the **Range Select Switch** and its markings).

g. Read the THD value. If the frequency or input level is changed while making measurements, the meter will go to zero for two or three seconds, and then it will display the new reading.

4.2.2 Measuring THD Level in dB below Input Signal

a. Follow steps a through e above.

b. THD can be now be read on the meter's dB scale. With the **Reference Set Control** is in the **THD dB** position, the reading will be in dB below maximum input signal (See Figure 6 on page 11 for a close-up view of the **Reference Set Control** and its markings.). If the frequency or input level is changed while making measurements, the meter will go to zero for two or three seconds, and then it will display the new reading.

4.2.3 Monitoring THD with an Oscilloscope.

It can help in interpreting the reading to observe the **Meter Monitor Output** on an oscilloscope, using the **Input Monitor Output** to synchronize the oscilloscope sweep. The observed waveform will be somewhat distorted due to the phase characteristics of the notch filter.

4.3 Intermodulation Distortion Mode

Intermodulation Distortion (IMD) is caused by the mixing of two or more signals that generate spurious signals. IMD is due to non-linear amplitude characteristics in an amplifier or other circuitry. It is essentially the same process as generating Amplitude Modulated signals, but generally at a far less efficient level than in a circuit designed for this purpose. Two signals, at frequencies F_1 and F_2, and at specific levels, are used for measuring IMD performance. Intermodulation products are defined as the sum and difference frequency products of the fundamental signal frequencies and/or their harmonics ($F_1 \pm F_2$, $2xF_1 \pm F_2$, $2xF_2 \pm F_1$, $3xF_1 \pm 2xF_2$, etc.).

The standard measurement technique for measuring IMD in broadcast equipment is to use a composite signal consisting of 60 Hz signal and a 7 kHz signal. The 7 kHz signal is at a voltage level that is one-fourth the voltage level of the 60 Hz signal. Such a standard composite IMD signal is available directly from the companion AG-51 Audio Generator, or the NAB Test CD (see Section 3.3.6 on page 16 for information about the NAB Test CD).

To measure IMD, the AA-51A filters out the 60 Hz signal and then demodulates the 7 kHz signal to measure any 60 Hz sidebands. The ratio of the sideband energy to the total energy, expressed as a percentage, is the measure of Intermodulation Distortion.

The test signal levels can be between 0.1 Vrms and 80 Vrms. The AA-51A does not accurately read values above 10%, and the readings with the **Range Select Switch** at higher positions are invalid.

To measure the percentage of IMD, use the following steps:

a. Apply an IMD source signal to the device under test, and at the desired signal level. The signal must have frequency and amplitude characteristics as described above.

b. Verify that the **Upper Mode Select Switch** is in its most counter-clockwise postion. Set the **Lower Mode Select Switch** in the **IMD** position.

c. Set the **Range Switch** to the 10% range.

d. Connect test leads from the device under test to the **L** or **R Input** connector and set the **Input Select Switch** appropriately to select the test signal.

e. With the device under test operating, note that the **Input Level High** and **Low LED** indicators are both OFF, indicating that the input level is within the range for accurate readings.

f. Adjust the Range Switch for an upscale reading to determine the IMD percentage. A dual-trace oscilloscope can help in determing the level at which the input starts to seriously distort. Connect the **Meter Monitor Output** to one channel of an oscilloscope, and monitor the **Input Monitor Output** on the other channel of the oscilloscope.

4.4 Noise Mode

The **Noise Mode** is a variation of the **Voltmeter Mode** described above. It is used to measure the ratio of Signal and Noise, to just Noise in the absence of a signal ([Signal + Noise] / Noise). The Noise measurements are performed with a restricted frequency bandwidth of 20 Hz to 20 kHz.

The following steps are used to measure the Signal-plus-Noise-to-Noise Ratio:

a. Apply a signal to the device under test at the desired frequency and signal level.

b. Verify that the **Upper Mode Select Switch** is in its most counter-clockwise postion. Set the **Lower Mode Select Switch** in the **NOISE** position.

c. Set the **Range Switch** to +30 dB (30 V).

d. Connect test leads from the device under test to the **L** or **R Inpu**t connector and set the **Input Select Switch** appropriately to select the test signal.

e. Adjust the **Range Switch** for an upscale reading. For convenience, the meter indication for the signal and noise may be adjusted to a convenient reference reading on the uppper dB scale by using the **Reference Set** control. Note the range and meter reading.

f. Disable the signal applied to the device under test.

g. Adjust the **Range Switch** switch for an upscale reading. Do not adjust the **Reference Set** control if it was used to obtain a reference reading. Note the difference in dB from the reading taken when the signal was ON and now, with the signal OFF. The difference is dB is the [Signal + Noise]/Noise ratio.

In the Noise mode, for sinewaves, the reference voltage applied must not exceed 8.0 Vrms up to 7.5 kHz, or 4.0 Vrms at 15 kHz for accurate results. If in doubt about the reading levels, monitor the **Meter Monitor Output** on an oscilloscope to ensure that the sinewave refererence signal is not distorted. For higher voltages, use the VM mode to establish the reference level. The meter sensitivity in the VM Mode is the same as for the NOISE Mode. Then switch to the Noise Mode to measure the restricted bandwidth noise amplitude with the signal OFF.

4.5 Phase Angle Mode

The **Phase Angle Mode** measures the phase angle between two signals. For proper stereo operation, it is important to maintain a strict phase relationship between the Left and Right signals. The companion AG-51 Audio generator can supply precision stereo output signals that are in phase (Left + Right) or that are 180 degrees out of phase (Left - Right).

The following steps are used to measure the phase difference between the Left and Right inputs:

a. Apply signals with a known phase relationship to the device under test. (The test signal phase relationship can be verified prior to test by using the following steps with the test generator connected directly to the AA-51A.)

b. Set the **Upper Mode Select Switch** to the **PHASE x10** position.

c. Connect the Left and Right signals into the Left and Right inputs of the AA-51A.

d. With signals applied, see that the HIGH and LOW LEDs are both out. If not, or if in doubt, switch to the VM mode and measure the input levels to ensure that they are within the specified range of 0.3 to 6.0 volts.

e. Read the meter's lower red scale (±15 corresponds to ±150 degrees). If the reading is less than 5 (50 degrees), switch the Upper Mode Select Switch to the **PHASE x3** position. In the **x3** position, read the meter's lower red scale (±15 correspond to ±45 degrees). Note the sign of the reading. A positive angle means that the Right input lags the Left input, or the Right input is delayed in time with respect to the Left input.

f. Fast phase changes may be observed on an oscilloscope by connecting to the Meter Monitor Output. The signal is a rectangular waveform, with the duty cycle proportional to the phase angle. A phase angle of zero degrees corresponds to a symmetrical square wave with a 50% duty cycle.

4.6 Ratio Mode

The ratio mode measures the amplitude difference between two signals. It may be used to ensure that the Left and Right stereo signals are of equal amplitude, or it may be used to ensure that different signal paths provide equal amplitude. The companion AG-51 Audio Generator provides equal amplitude and equal phase signals when used in the L+R mode.

The following steps are used to measure the amplitude ratio between the Left and Right inputs:

a. Apply signals of equal amplitude to the devices under test.

b. Set the **Upper Mode Select Switch** to the **RATIO** position.

c. Connect the Left and Right signals into the Left and Right inputs of the AA-51A.

d. With signals applied, see that the HIGH and LOW LEDs are both out. If not, or if in doubt, switch to the VM mode and measure the input levels to ensure that they are within the specified range of 0.3 to 6.0 volts.

e. Read the indicated ratio directly in dB on the **Meter's** upper red scale. A positive indication means that the **R**ight input is higher in level than the **L**eft input.

f. A DC voltage proportional to the ratio is available at the **Meter Monitor** output. A ratio of zero results in a DC voltage of zero. A +6 dB ratio results in a voltage of +3 VDC. A ratio of -6 dB results in a voltage of -1.5 VDC.

4.7 Wow and Flutter Mode

Wow and Flutter is the name given to slight variations in frequency, also commonly known as incidental FM. It is usually associated with turntables and tape machines where mechanical speed variations, warping, or stretching may vary the output frequency. Wow and flutter is expressed as a percentage of frequency deviation as compared to the the frequency used for testing.

The AA-51A measures weighted peak flutter as specified by IEEE Standard 193, using a 3.15 kHz (±10%) signal, at a level between 0.1 Vrms and 80 Vrms. The companion AG-51 Audio Generator provides a highly stable 3.15 kHz test signal, as does the NAB Test CD (see Section 3.3.6 on page 16 for information about the NAB Test CD).

The following steps are used to measure Wow and Flutter:

a. Set the **Upper Mode Switch** to **0.3% W&F**.

b. Connect test leads from the device under test to the **L** or **R Input** connector and set the **Input Select Switch** appropriately to select the test signal.

c. Verify that the HIGH and LOW LEDs are both OFF. If they are not, adjust the test level appropriately.

d. Observe the percentage of Wow and Flutter on the Meter's lower black scale. (A full scale reading of 3 corresponds to a Wow and Flutter value of 0.3%.

e. If the meter indication is small, set the **Upper Mode Switch** to **0.1% W&F**. Observe the percentage of Wow and Flutter on the Meter's upper black scale. (A full scale reading of 1 corresponds to a Wow and Flutter value of 0.1%).

f. The instantaneous output of the wow and flutter demodulator may be observed on an oscilloscope at the **Meter Monitor** output. The senstivity is constant for flutter frequencies from 0.2 to 200 Hz. There is no weighting filter at this point.

5 Factory Contact Information

By Postal Mail

Potomac Instruments, Inc.
932 Philadelphia Avenue
Silver Spring, Maryland 20910
USA

By Telephone or Fax

Tel. 1-301-589-2662
Fax 1-301-589-2665
Country Code 1, North American Area Code 301
North American Eastern Time Zone (GMT -5)

By Internet/World Wide Web

Website: http://www.PI-USA.com
E-Mail: sales@PI-USA.com

Please check our website for the latest technical notes, information, and worksheets. The latest revision of this technical manual is also available for viewing and downloading from our website.

Appendix A. Return Material Authorization Form

PI Potomac Instruments, Inc.

Potomac Instruments, Inc.
932 Philadelphia Ave.
Silver Spring, MD 20910
Tel 1-301-589-2662
Fax 1-301-589-2665
Internet http://www.pi-usa.com

Return Material Authorization

RMA # Issued: ____________

Information Request

Equipment Information

Model Number	Serial Number	Warranty Claim ❑Yes ❑No

Primary and Alternate Customer Contacts

Name	Telephone	Fax	E-Mail
Name	Telephone	Fax	E-Mail

Shipping and Billing Information

	Shipping	Billing
Attention		
P.O. Number		
Suite / PO Box		
City, State, ZIP, Country		

Nature of Service Requested, Symptoms Observed, Additional Information and Special Instructions

Please fill out any blank boxes as completely as possible. Enclose a copy of this RMA with your outbound shipment to the address at the top of this form. IF you have any questions about this form, please contact our service department.

Credit Terms: All parts and service invoices are restricted to one of the following:

1.) Credit Card Transaction (Visa or Master Card)
2.) Payment in Full prior to shipment (CIF)