AUX-0025

Switching Amplifier Measurement Filter

USER'S MANUAL

Audio precision®

AUX-0025
User's Manual

Installation and Operation of the

AUX-0025
Switching Amplifier Measurement Filter

Audio precision®

Audio Precision part number 8211.0180 Rev 0

Published by:

Audio precision®

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Printed in the United States of America

III0204081903

Contents

Safety

The two AUX-0025 front-panel terminals marked with this sign are a chassis common connection. They are NOT a safety ground, and are not intended for use as a safety ground connection.

Chapter 1

Introduction

Figure 1. The Audio Precision AUX-0025 Switching Amplifier Measurement Filter.

Audio analyzers are generally designed to have broad measurement bandwidths, broader than a typical audio circuit or system and much wider than the audio passband. Such designs enable accurate analysis of fast, high-performance audio circuits and also allow measurement of any low-level high-frequency spurious signals that may accompany the audio signal.

This design philosophy is based on the assumption that the audio signal and its overtones are the dominant signal components applied to the analyzer; this is the case for the output of conventional audio power amplifiers of Class A or Class AB design. In such a case the analyzer can range its circuits to the amplitude of the audio signal for optimum measurement conditions.

Recent practice, however, has often turned to other amplifier designs for improvements in efficiency and weight as compared to Class A and Class AB amplifiers. Although these amplifier designs vary, as do the names applied to them, they have in common an output signal that is a high-frequency switching carrier modulated by the audio signal. Many of these "switching amplifiers" or "digital amplifiers" present a difficulty to conventional measurement and analysis techniques due to the out-of-band switching carrier components that are in the output signal. When the amplitude of the switching carrier components remains high in comparison to the

audio signal, the ranging functions of an audio analyzer may respond to the carrier rather than to the audio signal, reducing the accuracy of the measurements.

The best solution in using a broad range, broad bandwidth analyzer to accurately measure the output of such an amplifier is to insert a carefully-designed low-pass filter between the output of the device under test (DUT) and the analyzer input to reduce amplitude of the switching carrier before the signal is ranged. The Audio Precision AUX-0025 Switching Amplifier Measurement Filter fulfills this requirement.

A Switching Amplifier by any name...

In this document we will refer to audio amplifiers with modulated switching carrier outputs as *switching amplifiers;* in other literature the term *switchmode amplifier* may be used. These devices include Class D, Class I and Class S amplifiers and also Class T amplifiers and "digital amplifiers."

Generally, switching amplifiers impose the audio signal on the carrier by pulse width modulation (PWM). (Class T is a variation on this, adding a dynamic modulation of the carrier frequency and other signal processing).

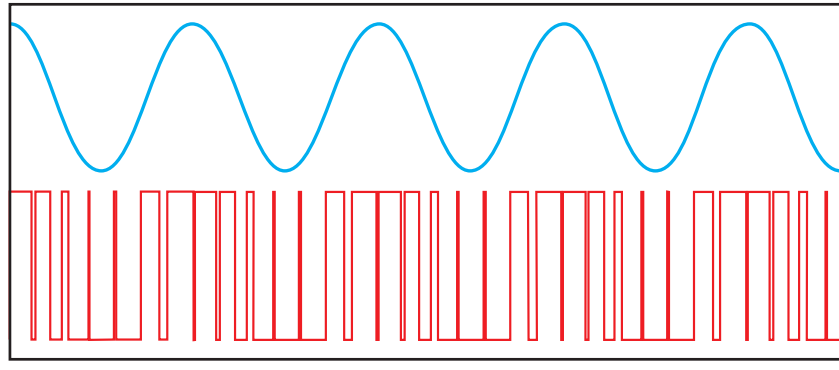

Figure 2. A diagram of a sine wave and a pulse width modulated (PWM) switching carrier modulated by the same wave.

Switching amplifiers designed for a limited bandwidth (such as subwoofer amplifiers) may use a carrier frequency as low as 80 kHz. Full-range amplifiers have higher carriers, up to 1.5 MHz or more.

Some switching amplifiers provide no filtering at their output and depend upon the inductance and mass of the loudspeaker to integrate the signal, reproducing the audio but not the inaudible carrier. Other amplifiers include an output low-pass filter, which reduces EMI and aids the loudspeaker in integrating the signal, but which is generally not sufficient for accurate measurement by an external analyzer.

Features of the AUX-0025

The AUX-0025 is a dual-channel passive low-pass filter specifically designed to minimize switching amplifier carrier components while passing a broad audio spectrum. This filter provides the signal preconditioning necessary to accurately measure switching amplifier outputs using a wide-range audio analyzer.

Passive design

For this application, a passive filter was determined to be the best approach. An active filter would require input attenuation and variable gain to accommodate the wide range of signal amplitudes that might be applied, adding noise and distortion to the signal.

Inductors

Custom inductors were specified with an emphasis on power handling and minimizing low-frequency distortion while satisfying the filter response requirements.

Connectors

The AUX-0025 input connectors duplicate the balanced female XLR-type and dual-banana jacks found on Audio Precision System 2000 Series instruments. A common connection is conveniently provided next to each channel input. The common terminal will accept a banana plug or a bare wire connection.

The filtered outputs of the AUX-0025 are provided on balanced male XLR-type connectors.

Cables

For proper performance, the analyzer input impedance that the AUX-0025 looks into must be high, with a maximum total capacitive loading (including interconnecting cables) of 360 pF. Two short, low-capacitance XLR-to-XLR cables are provided for the connection between the AUX-0025 and the analyzing instrument to help ensure a proper loading.

Mounting

The AUX-0025 is fitted with resilient feet for tabletop use. It can also be rack-mounted using the optional rack mount adapters available from Audio Precision. Being a passive unit, the AUX-0025 does not dissipate appreciable power and requires no extraordinary ventilation considerations.

The AUX-0025 should not be mounted close to a source of strong magnetic fields such as a power transformer. Stray magnetic fields could cause degradation in system residual hum and noise performance.

Audio Precision products such as the System 2000 Series and ATS-2 instruments are designed to minimize and contain stray magnetic and electrostatic fields that may be produced within the instrument. The AUX-0025 may be placed directly on top of Audio Precision instruments with no degradation in system performance.

Chapter 2

Using Your AUX-0025

Connections

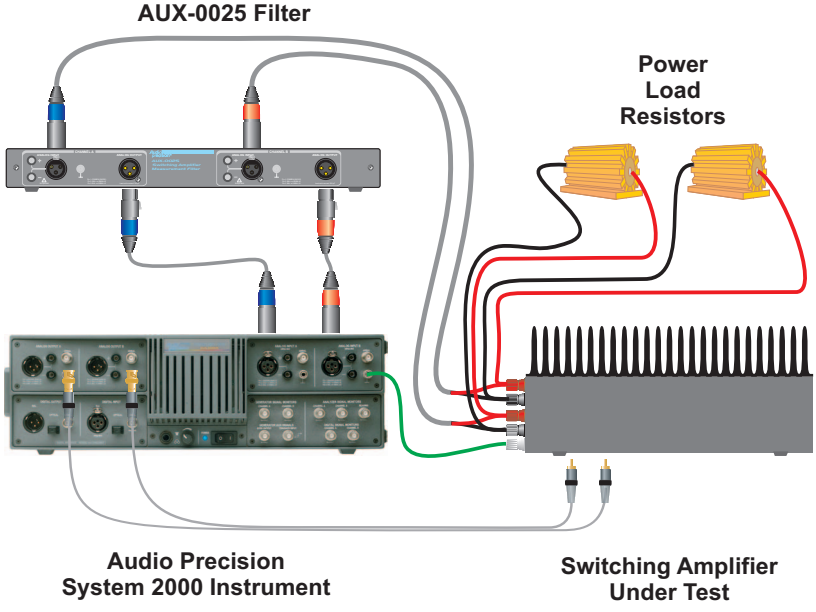

Figure 3. Diagram of a switching amplifier output properly connected to the AUX-0025 (and analyzer) and to an amplifier load.

Connecting the DUT to the AUX-0025

For a DUT with balanced outputs

- connect the high side of the amplifier output to the top banana connector (marked +) or to pin 2 of the female XLR-type connector, and

- connect the low side of the amplifier output to the bottom banana connector (marked –) or to pin 3 of the female XLR-type connector.

For a DUT with unbalanced outputs

- connect the amplifier output to the top banana connector (marked +) or to pin 2 of the female XLR-type connector, and
- connect the amplifier common or ground to the bottom banana connector (marked –) or to pin 3 of the female XLR-type connector.

Common connections should be made to the common terminal for each channel, marked with this symbol.

Connecting the DUT to a Load

Although useful measurements can be performed on switching amplifier outputs when unloaded, it is usually desirable to measure the amplifier performance while working into a load, whether a resistive "dummy load" or an actual loudspeaker.

When using the AUX-0025 in a test with a load, be sure that the measurement connections are made at the point physically and electrically closest to the amplifier output circuitry, rather than at the load. The very slight reduction in connection and wire impedance obtained using this practice will provide more accurate and consistent amplifier output measurements.

Connecting the AUX-0025 to the Analyzer

For proper performance, the analyzer input impedance that the AUX-0025 looks into must be high. (The DUT output impedance must be low [<2 Ω] as well, but this is consistent with switching amplifier designs.)

For Audio Precision analyzer instruments, use the **HiZ** setting. Never terminate the AUX-0025 outputs with an impedance less than 100 kΩ resistive or greater than 360 pF capacitive.

The high side of the AUX-0025 output is on pin two of each of the XLR-type output connectors. The low side is carried on pin three while pin one is the shield termination, connected to the AUX-0025 chassis common. The AUX-0025 can be connected to either a balanced or unbalanced analyzer input, as long as the input, cables and adapters used do not present a load impedance less than 100 kΩ resistive or greater than 360 pF capacitive.

Two short, low-capacitance XLR-to-XLR cables are provided for the interconnection between the AUX-0025 and the analyzing instrument to help maintain a high load impedance and recommended load capacitance.

Typical waveforms

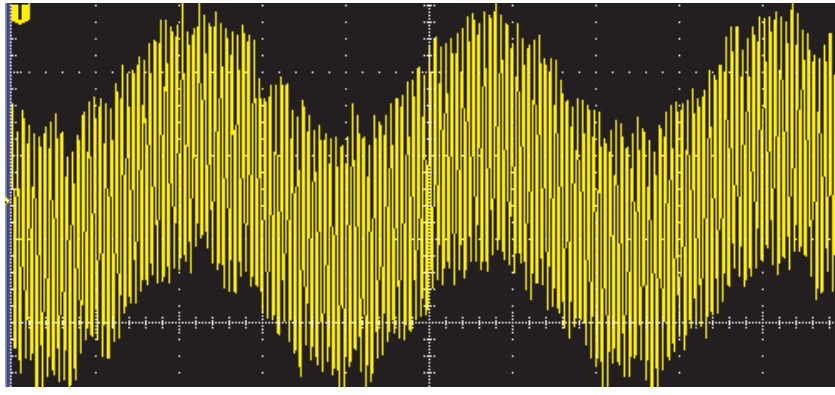

Figure 4. An oscilloscope capture of a switching amplifier output signal. The high-frequency, high-level switching carrier is shown riding the lower-frequency audio

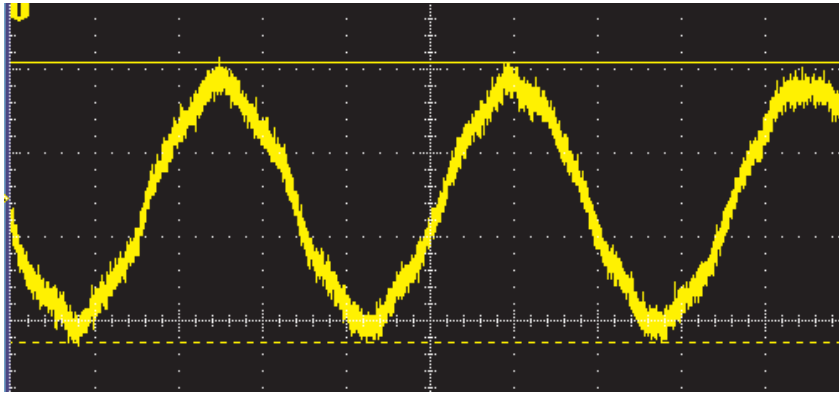

Figure 5. An second oscilloscope capture of the sane switching amplifier output as shown in Figure 4, after the application the AUX-0025 filter. The switching carrier has been greatly reduced.

The two oscilloscope traces shown in Figures 4 and 5 show time-domain views of the unfiltered and filtered output for a particular amplifier. Different amplifiers and load configurations can produce oscilloscope waveforms that are quite different than these.

Use of additional filters

The AUX-0025 filter reduces the switching carrier and other out-of-band components to a sufficient degree for accurate measurement, but it is not designed to remove all out-of-band noise.

In many cases you may want to apply additional low-pass filtering within the analyzer. Both the Audio Precision ATS-2 and the System 2000 instruments have additional filtering available.

A standardized and very effective technique to reduce out-of-band components for measurement is the use of the Audio Precision S-AES17 filter set, available for System 2000 Series instruments.

Use with SWR-2122 switchers

The characteristics of the Audio Precision SWR-2122 series switchers are completely compatible with the AUX-0025. The appropriate balanced or unbalanced switcher can be used to automatically switch the filter / instrument inputs among several DUTs.

Sample Tests

The CD-ROM provided with your AUX-0025 has a selection of sample Audio Precision tests for use with switching amplifiers. Open the file Readme.doc for a description of the sample test files.

For more information about your AUX-0025 Switching Amplifier Measurement Filter and switching amplifiers in general, visit the Audio Precision Web site at audioprecision.com.

Chapter 3

Specifications

Specifications

Frequency Response	±0.05 dB, 10 Hz to 20 Hz
Insertion Loss	0.05 dB, typically
High-frequency Rejection	>50 dB, 250 kHz to 20 MHz, typically
Maximum Input	±200 V peak
Interchannel Crosstalk	>90 dB at 20 kHz
Distortion	< –110 dB harmonic (measured at 70 Vpp, 1 kHz) < –100 dB IMD (measured at 70 Vpp with 18 kHz and 20 kHz dual tone test signal. IMD components are at 2 kHz, 16 kHz and 22 kHz.)

Dimensions

Temperature Range	
Operating	+5º C to +40º C
Storage	–40º C to +75º C
Humidity	80% RH to at least +90º C
Dimensions	16.5 x 1.75 x 10.5 inches (41.9 x 4.4 x 26.7 centimeters)
Weight	7.2 lb (3.3 kg) unpacked

Filter Response Graphs

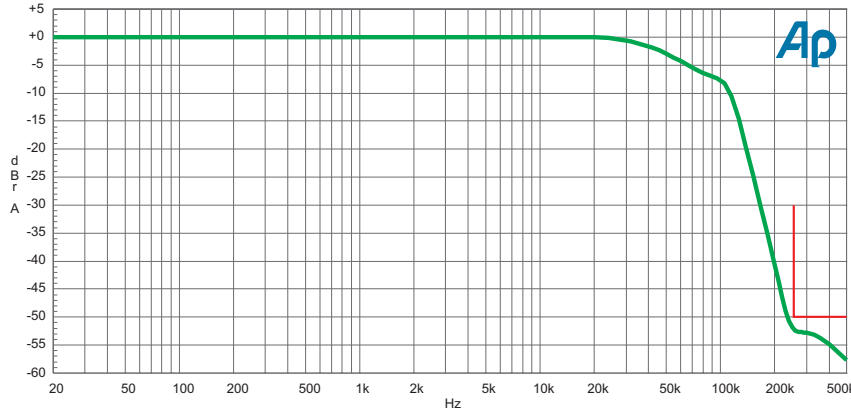

Figure 6. AUX-0025 overall response showing attenuation beyond the audio band.

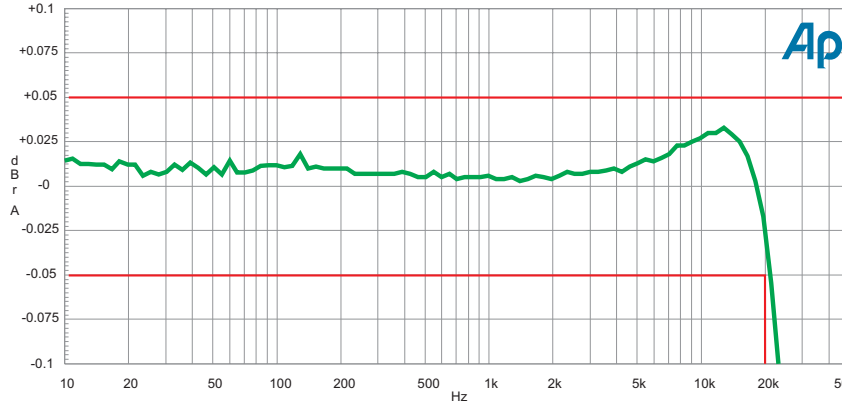

Figure 7. AUX-0025 passband response showing flatness out to 20 kHz.