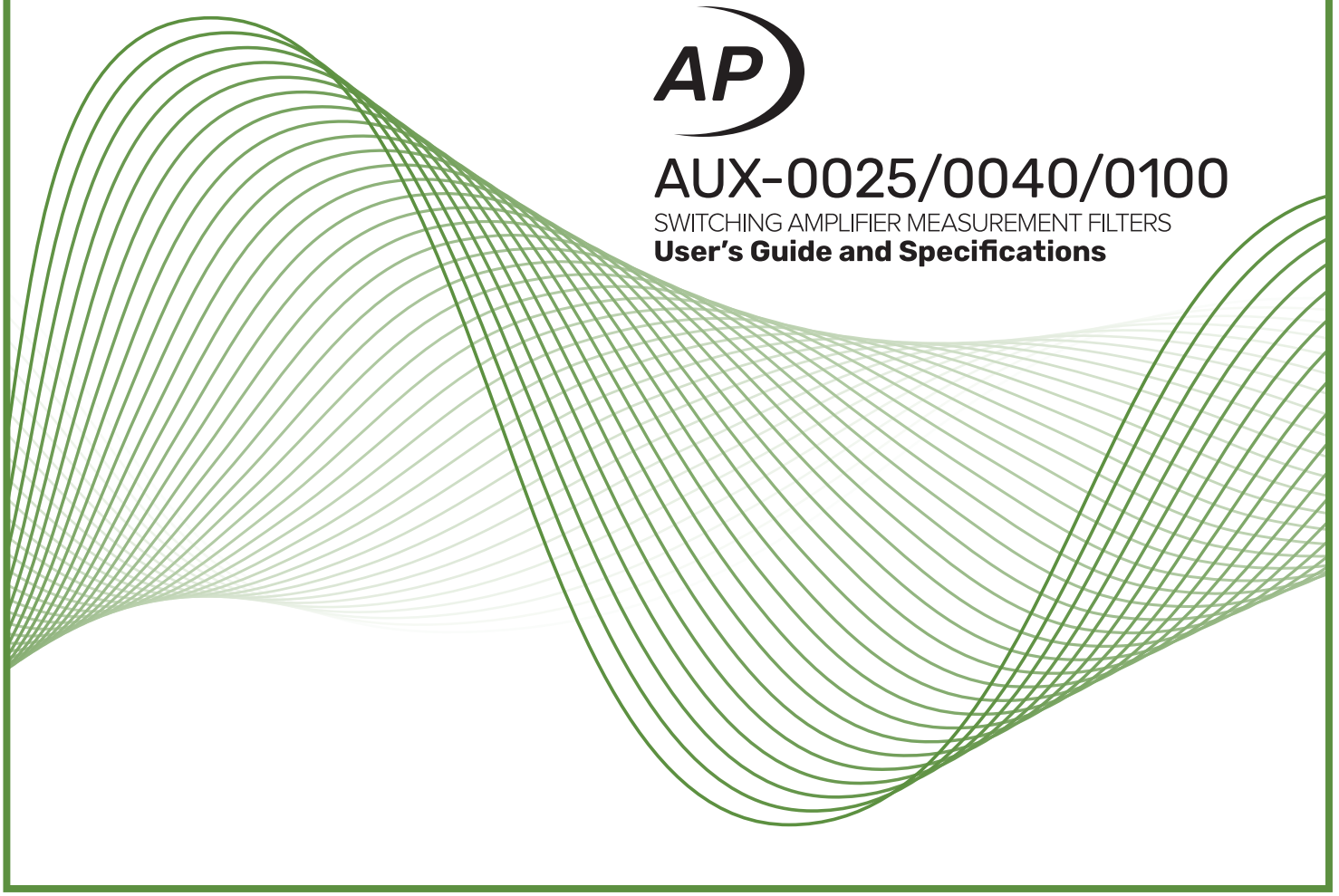

AUX-0025/0040/0100

SWITCHING AMPLIFIER MEASUREMENT FILTERS

User's Guide and Specifications

AUX 0025, AUX-0040 and AUX-0100 Switching Amplifier Measurement Filters

User's Guide and Specifications

AUX-0025

December, 2023

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XXIII1208143723

Documentation and Support

This booklet contains safety information, installation instructions and full specifications for the Audio Precision AUX-0025/0040/0100 Switching Amplifier Measurement Filters. The AUX series of filters are accessories to any Audio Precision audio analyzer.

ap.com

Visit the Audio Precision Web site at ap.com for APx support information. APx resources are available at ap.com. You can also contact our Technical Support staff at techsupport@ap.com, or by telephoning 503-627-0832 ext. 4, or 800-231-7350 ext. 4 (toll free in the U.S.A.).

Contents

Safety

Safety Information

Do NOT service or repair this equipment unless properly qualified. Servicing should be performed only by a qualified technician or an authorized Audio Precision distributor.

Do NOT substitute parts or make any modifications without the written approval of Audio Precision. Doing so may create safety hazards. Using this product in a manner not specified by Audio Precision can result in a safety hazard.

This product is for indoor use—Installation Category II, Measurement Category I, pollution degree 2.

To clean the enclosure of this product, use a soft cloth or brush to remove accumulated dust. A mild detergent may be used to remove remaining dirt or stains. Do not use strong or abrasive cleaners. Wipe all surfaces with a damp cloth.

Safety Symbols

The following symbols may be marked on the panels or covers of equipment or modules, and are used in this manual:

WARNING!—This symbol alerts you to a potentially hazardous condition, such as the presence of dangerous voltage that could pose a risk of electrical shock. Refer to the accompanying Warning Label or Tag, and exercise extreme caution.

ATTENTION!—This symbol alerts you to important operating considerations or a potential operating condition that could damage equipment. If you see this marked on equipment, refer to the Operator's Manual or User's Manual for precautionary instructions.

FUNCTIONAL EARTH TERMINAL—A terminal marked with this symbol is electrically connected to a reference point of a measuring circuit or output and is intended to be earthed (grounded) for any functional purpose other than safety.

PROTECTIVE EARTH TERMINAL—A terminal marked with this symbol is bonded to conductive parts of the instrument and is intended to be connected to an external protective earthing (grounding) system.

Disclaimer

Audio Precision cautions against using their products in a manner not specified by the manufacturer. To do otherwise may void any warranties, damage equipment, or pose a safety risk to personnel.

Introduction

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; also, the slew rate of the analyzer input amplifiers may be exceeded. Either will reduce the accuracy of the measurements.

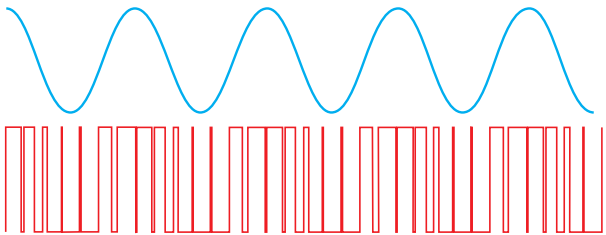
The best solution in using a broad range, broad bandwidth analyzer to accurately measure the output of such an amplifier is to insert a carefully designed low-pass filter between the output of the device under test (DUT) and the analyzer input to reduce amplitude of the switching carrier before the signal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

AUX-0025, AUX-0040 and AUX-0100 family of switching amplifier measurement filters 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.)



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 filters

Each channel of an AUX-0025/0040/0100 is a passive low-pass filter specifically designed to minimize switching amplifier carrier components while passing a broad audio spectrum. The filter provides the signal preconditioning necessary to accurately measure switching amplifier outputs using a wide-range audio analyzer.

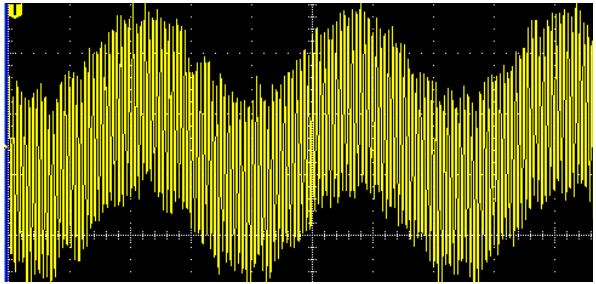
Passive design

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.

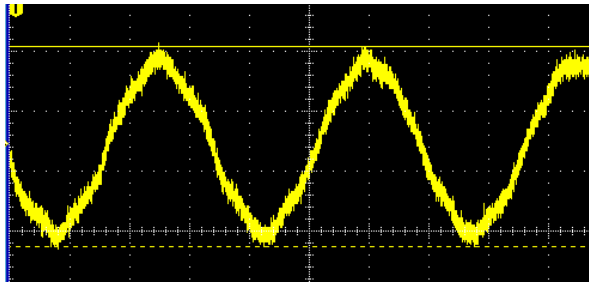
Inductors

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

Typical waveforms



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



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

The two oscilloscope traces above 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 filters reduce the switching carrier and other out-of-band components to a sufficient degree for accurate measurement, but they are not designed to remove all out-of-band noise.

In many cases you may want to apply additional low-pass filtering within the analyzer.

Mounting

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

The AUX filter 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 analyzers are designed to minimize and contain stray magnetic and electrostatic fields that may be produced within the instrument. An AUX-0025/0040/0100 filter may be placed directly on top of an Audio Precision analyzer with no degradation in system performance.*

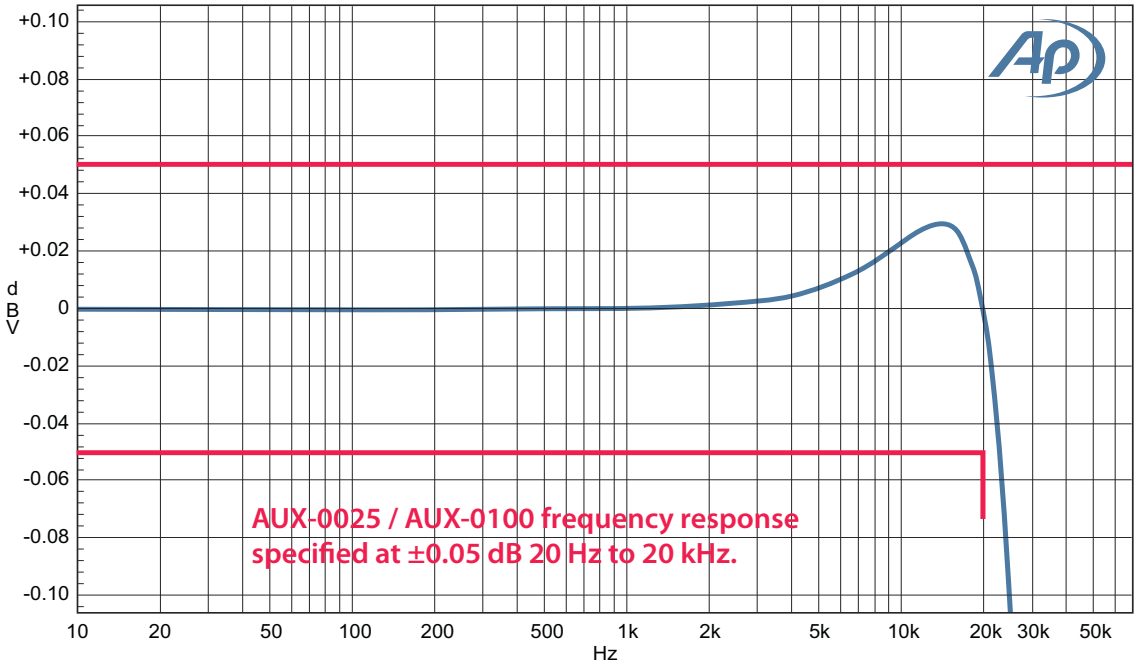
Use with Audio Precision switchers

The characteristics of the Audio Precision SWR-2122 or SWR-2755 series switchers are completely compatible with the AUX-0025/0040/0100. The appropriate balanced or unbalanced switcher can be used to automatically switch the filter / instrument inputs among several DUTs.

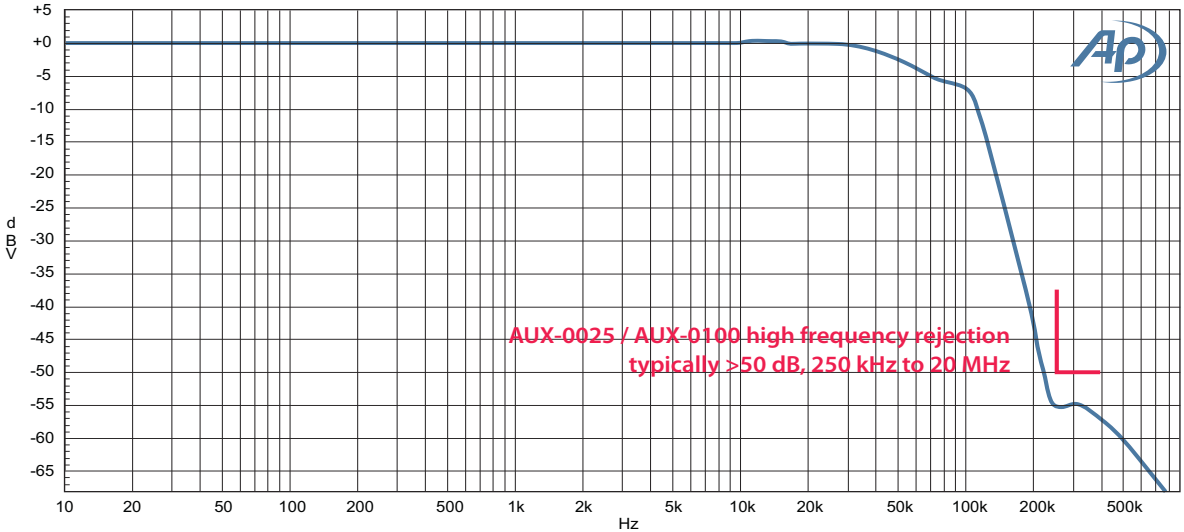
For more information about your Switching Amplifier Measurement Filter and switching amplifiers in general, visit the Audio Precision Web site at ap.com.

Typical Response Curves

AUX-0025 and AUX-0100

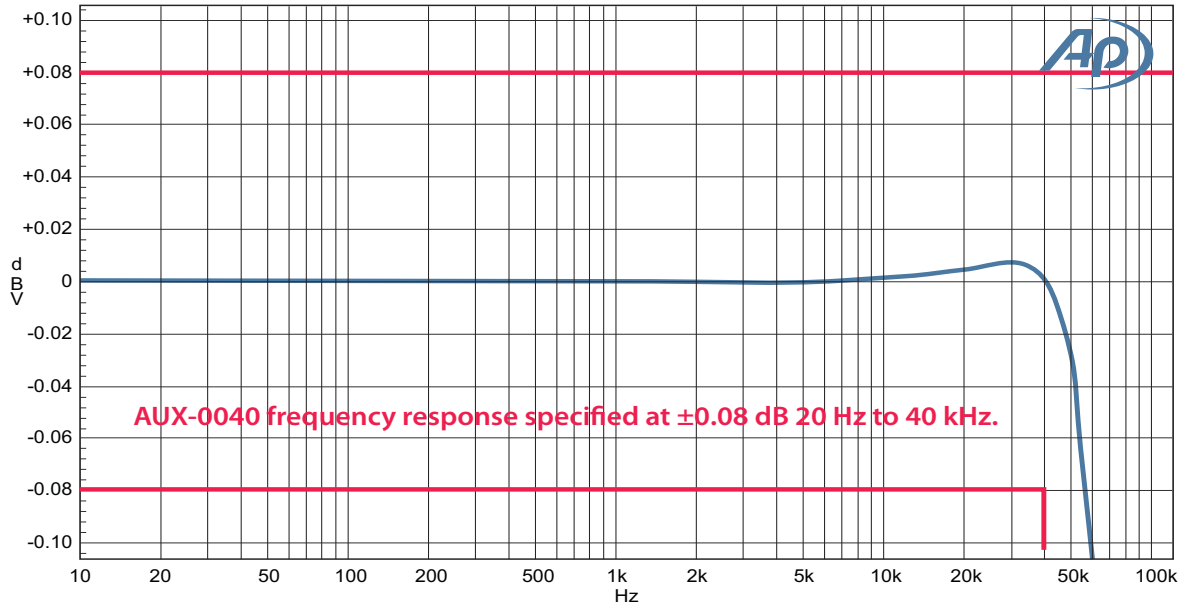


AUX-0025 and AUX-0100 filter passband

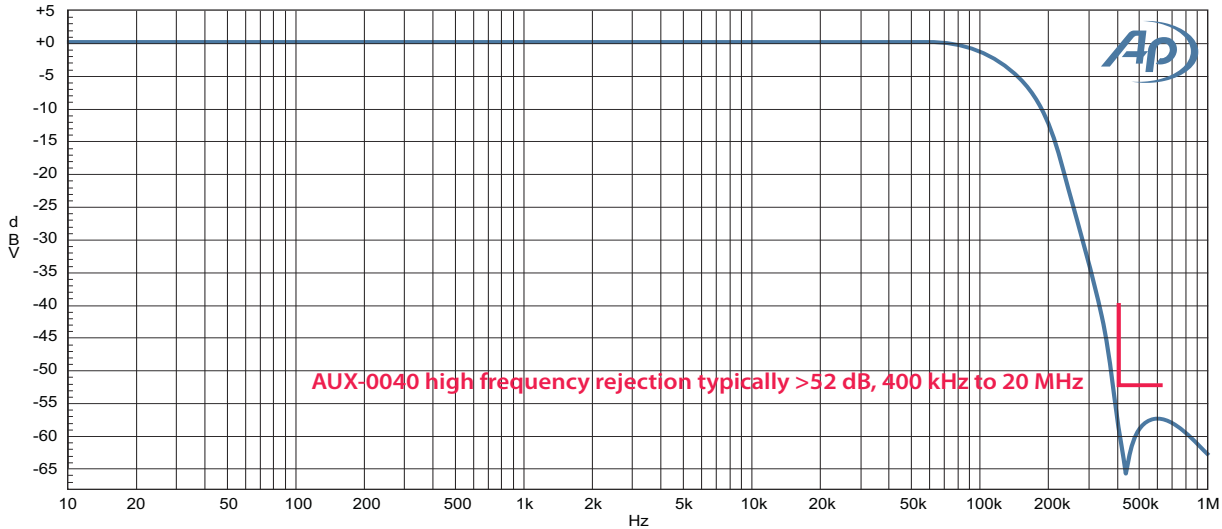


AUX-0025 and AUX-0100 filter cutoff

AUX-0040



AUX-0040 filter passband



AUX-0040 filter cutoff

User's Guide

AUX-0025

AUX-0040

AUX-0100

The three filters discussed here are quite similar. The two-channel AUX-0025 and AUX-0040 share the same mechanical design and connectors, but differ in their bandpass: the AUX-0025 has a flat response from 20 Hz to 20 kHz with a sharp cutoff above that point, while the AUX-0040 extends its response to 40 kHz before falling off.

The eight-channel AUX-0100 has the same 20 Hz to 20 kHz response as the AUX-0025, but is AC coupled.

For proper performance, the analyzer input impedance that the AUX filters look 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 APx analyzers, use the default analog balanced setting of 200 kΩ. For legacy Audio Precision instruments, use the HiZ setting. Never terminate the filter outputs with an impedance less than 100 kΩ resistive or greater than 360 pF capacitive. 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

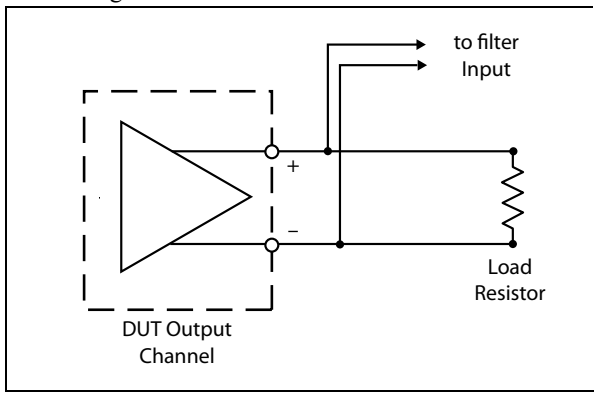
- connect the amplifier output to the top banana connector (marked +) or to pin 2 of the female XLR-type connector, and
- connect the amplifier common or ground to the bottom banana connector (marked –) or to pin 3 of the female XLR-type connector.

Common connections should be made to the common terminal.

Connections

Using load resistors

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. Dale NH-250 non-inductive 1% 250 watt resistors are commonly available in a number of different values, and are a good choice for power amplifier loading.



Connection detail, DUT output, AUX filter input and load resistor.

When using an AUX-0025/0040/0100 filter in a test with a load, connect each filter input in parallel with the load

across the amplifier output, as shown above. 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.

Filter Input Connectors

The AUX-0025, AUX-0040 and AUX-0100 inputs provide the same balanced female XLR-type connectors and dual-banana jacks that are found on Audio Precision analyzer inputs. Two front-panel common (chassis) connections (one, in the case of the AUX-0100) are provided. The common terminal will accept a banana plug or a bare wire connection.

Filter Output Connectors

AUX-0025 and AUX-0040

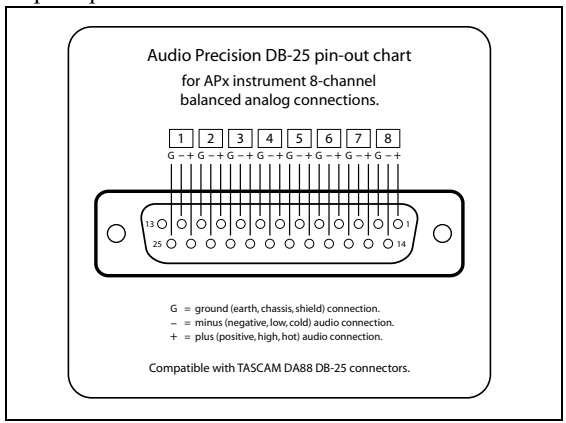
For the AUX-0025 and AUX-0040, the filtered outputs are provided on balanced male XLR-type connectors. The high side of the filter output is on pin 2 of each of the XLR-type output connectors. The low side is carried on pin 3, while pin 1 is the shield termination, connected to the filter chassis common.

The AUX-0025/0040 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 filter and the analyzer to help maintain a high load impedance and recommended load capacitance.

AUX-0100

The diagram below shows the DB-25 connector wiring, which matches the TASCAM standard for 8-channel audio interconnection. The AUX-0100 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.



DB-25 pin-out chart.

Connecting the AUX-0025 or AUX-0040

Use the Audio Precision CAB-DB1 cable for the inter-connection between the AUX-0100 and an APx500 Series instrument to maintain a high load impedance and recommended load capacitance.

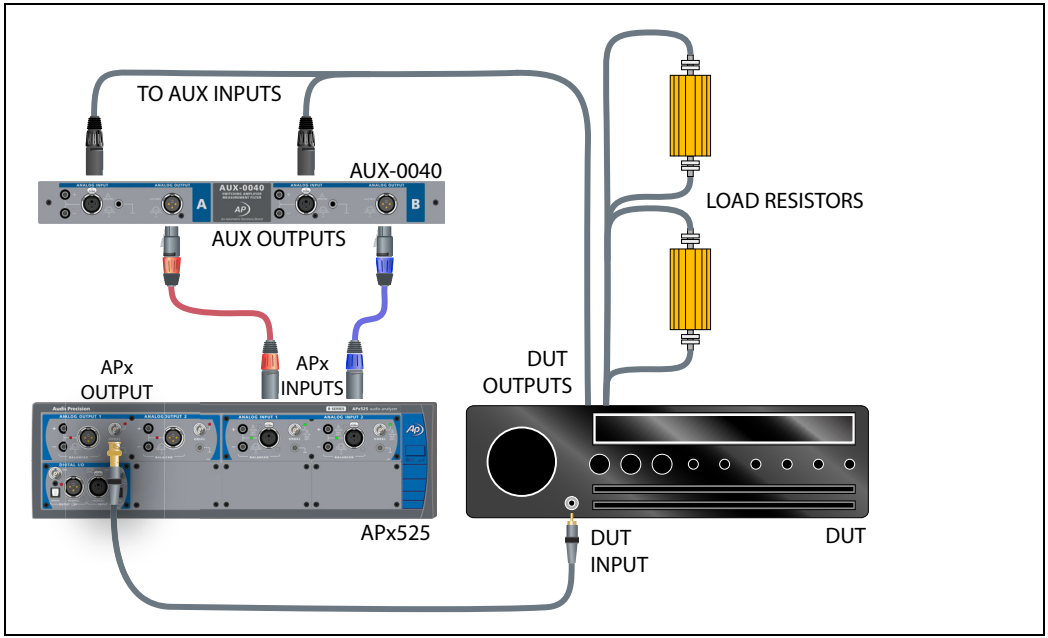


Diagram representing a switching amplifier whose outputs are connected to both the AUX-0025/AUX-0040 and to load resistors.

Connecting the AUX-0100

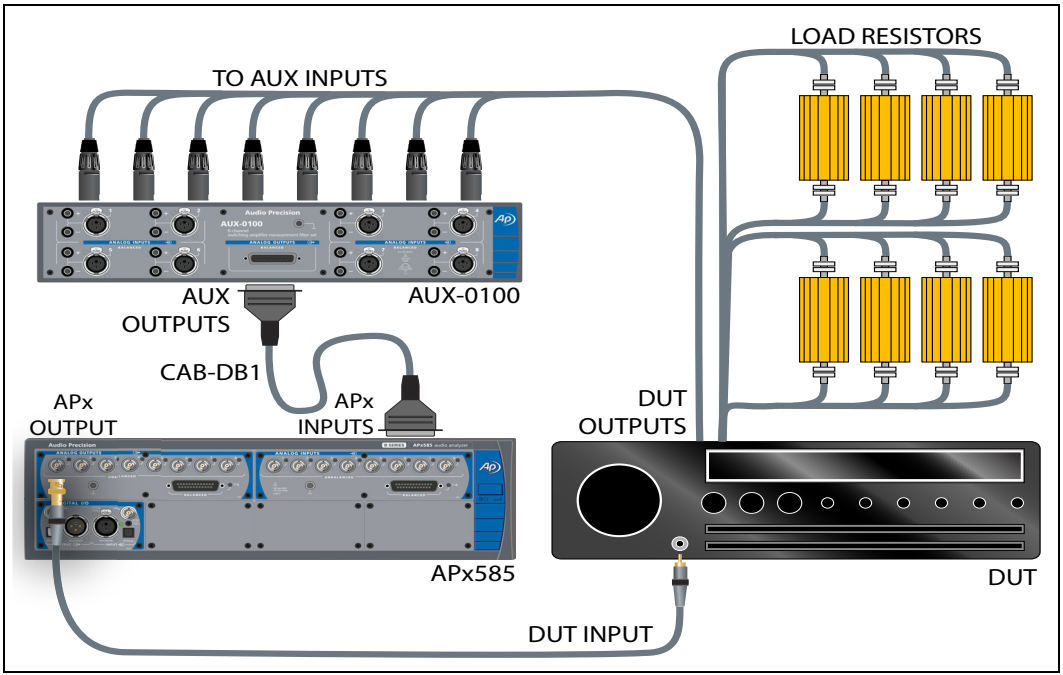


Diagram representing a switching amplifier whose outputs are connected to both the AUX-0100 and to load resistors.

Abbreviations, Terms and Symbols

used in the following specifications

ADC or A/D . . . . . Analog to Digital converter or conversion.
BW . . . . . Bandwidth or Measurement Bandwidth, nominally at –3 dB; a single number indicates only the upper limit.
DAC or D/A . . . . . Digital to Analog converter or conversion.
DSP . . . . . Digital Signal Processing or Digital Signal Processor.
DUT . . . . . Device Under Test, the device to which the generator or analyzer is connected.
EMC . . . . . Electro-Magnetic Compatibility, usually refers to both emissions (radiated and conducted via AC mains) and susceptibility.
ENBW . . . . . Equivalent Noise Bandwidth, the frequency of an ideal filter having the same rms response to white noise.
FFT . . . . . Fast Fourier Transform, a mathematical process converting a signal in the time domain to the frequency domain.
IMD . . . . . Inter-Modulation Distortion, a measure of non-linearity using a test signal with two or more components.
RMS or rms . . . . . Root Mean Square, an equivalent-power expression of signal amplitude.
SR . . . . . Sample Rate, usually as it applies to the conversion rate of A/D and D/A converters or digital audio formats.
THD . . . . . Total Harmonic Distortion, rms summation of d2 to d9 (may be bandwidth limited), usually derived from an FFT.
THD+N . . . . . Rms measurement of ALL harmonics, spurious signals, and noise within a specified bandwidth.
Typical or Typ . . . . . A characteristic that is not guaranteed, usually due to a practical limitation in testing or metrology.
UI . . . . . Unit Interval, a measure of time as it applies to digital audio formats.
1 UI=1/(128 • SR)
[ ] . . . . . Indicates a specification in an equivalent unit, for example: 0.030 dB [0.35%] or 10.61 Vrms [30.00 Vpp].
≈ . . . . . Indicates an approximate or nominal value, or range of values; not guaranteed.

Specifications

AUX-0025 / AUX-0040 / AUX-0100 Switching Amplifier Measurement Filters

December 2016 NP0020.00026 r000

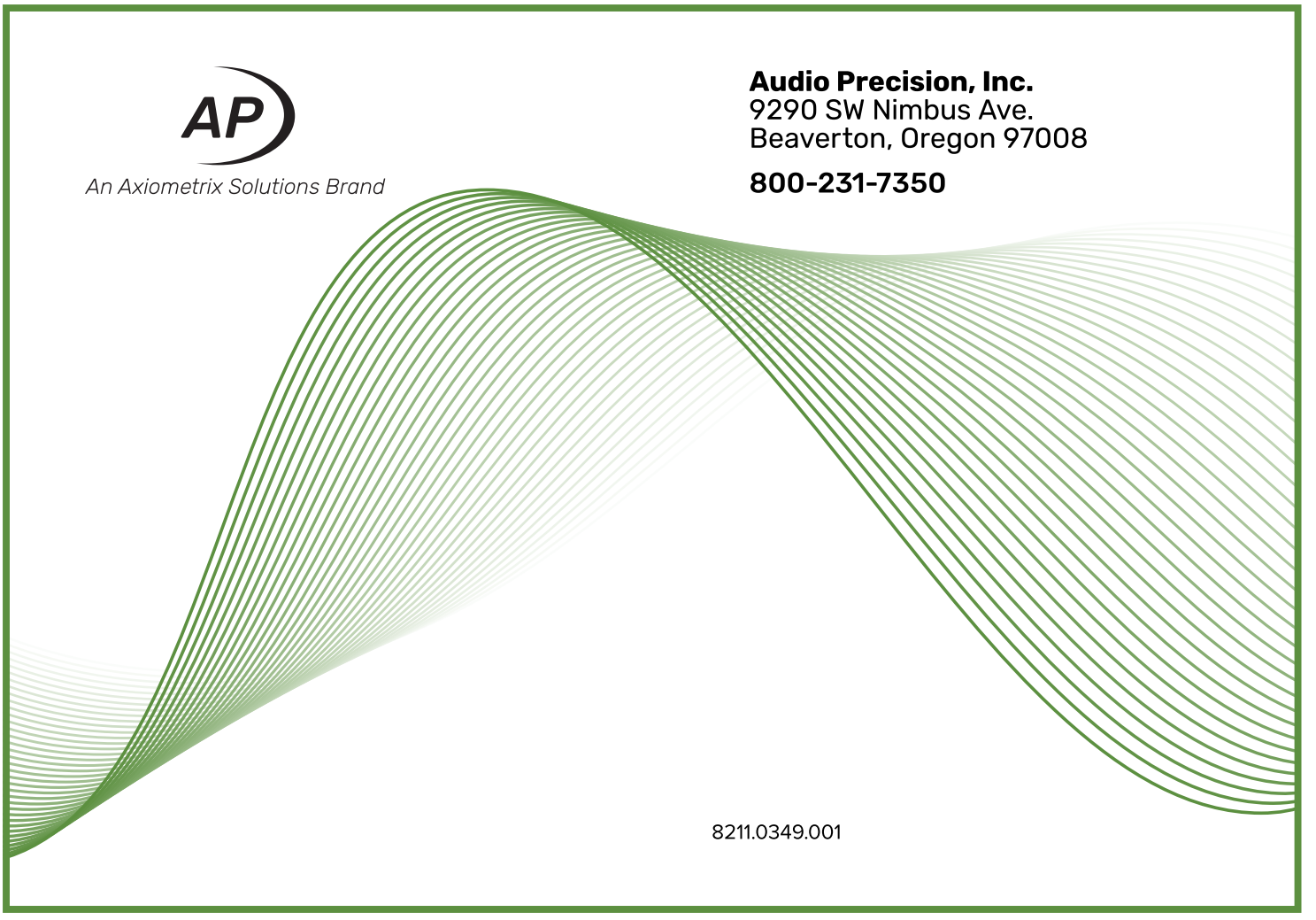
Characteristic	Specifications	Supplemental Information
ELECTRICAL		
Maximum Rated Input[1]		
AUX-0025, AUX-0100	±200 Vpk [140 Vrms], dc to 7.5 kHz, decreasing to 75 Vpk [53 Vrms] from 20 kHz to 2 MHz	
AUX-0040	±200 Vpk [140 Vrms], dc to 15 kHz, decreasing to 75 Vpk [53 Vrms] from 40 kHz to 2 MHz	
Frequency Response[2,3]		
AUX-0025, AUX-0100	±0.05 dB, 20 Hz to 20 kHz	*AUX-0025 is dc coupled, AUX-0100 is ac coupled*
AUX-0040	±0.08 dB, 20 Hz to 40 kHz	AUX-0040 is dc coupled
Insertion Loss[2]		*Typically –0.054 dB*
High-Frequency Rejection		
AUX-0025, AUX-0100		*Typically >50 dB, 250 kHz to 20 MHz*
AUX-0040		Typically >52 dB, 400 kHz to 20 MHz
Interchannel Crosstalk		

Characteristic	Specifications	Supplemental Information
AUX-0025, AUX-0040	90 dB at 20 kHz	
AUX-0100	82 dB at 20 kHz	
Distortion[4]		
THD+N (1 kHz)	–110 dB	*40 kHz measurement bandwidth*
DFD (18 kHz+20 kHz)	–100 dB per IEC60268	*Measured IMD products are at 2 kHz (d2) and 16 kHz + 22 kHz (d3)*
GENERAL / ENVIRONMENTAL		
Power Requirements	None	
Temperature Range		
Operating	0 °C to +45 °C	
Storage	–40 °C to +75 °C	
Humidity	90 % to +40 °C (non-condensing)	
Max Operating Altitude	3000 m	
Stabilization Time	None	
Dimensions		
AUX-0025, AUX-0040	419 x 44 x 267 mm [16.50 x 1.75 x 10.51 inches]	
AUX-0100	426 x 80 x 263 mm [16.75 x 3.14 x 10.34 inches]	
Weight		
AUX-0025, AUX-0040	3.3 kg [7.2 lbs]	
AUX-0100	5.2 kg [11.5 lbs]	

Characteristic	Specifications	Supplemental Information

NOTES to SPECIFICATIONS:

1 Intended for testing switch-mode (class-D) amplifiers rated up to 1000 W into 8 Ω at low frequencies.
2 Source impedance must be <2 Ω to 20 kHz (or <2.5 Ω to 40 kHz); analyzer input must be 100 kΩ, each side to ground.
3 Total loading capacitance of the analyzer input and interconnection cable must not exceed 360 pF, each side to ground.
4 Measured at 25 Vrms with 40 Ω balanced source impedance.



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