



Switching Amplifier Measurement Filter

Model AUX-0025

Manufacturers of power amplifiers are moving to switching designs (also called Class D or switch-mode) to make their amplifiers lower cost and more efficient compared to conventional linear power amplifier designs. This technology has particular appeal in automotive and personal stereo applications where efficiency, low battery consumption, small size, and low cost are desired. However, amplifiers using this technology present new measurement challenges. The switching process adds fast edges at the switching frequency to the audio output signal. These fast edges are of no consequence to the typical load, a loudspeaker, but present a difficult signal for measurement instruments. The fast switching edges present high energy content and will introduce slew rate limiting when presented to the input stage of most measurement instruments. When stressed by these fast edges, the analyzer input amplifier will usually slew rate limit and will not be able to function effectively in its normal mode. Auto ranging will be affected and the signal under test will be misrepresented to the following measurement circuits. The result is that noise and distortion measurements of switching amplifiers with almost any analyzer without preconditioning will yield inaccurate and unpredictable results.

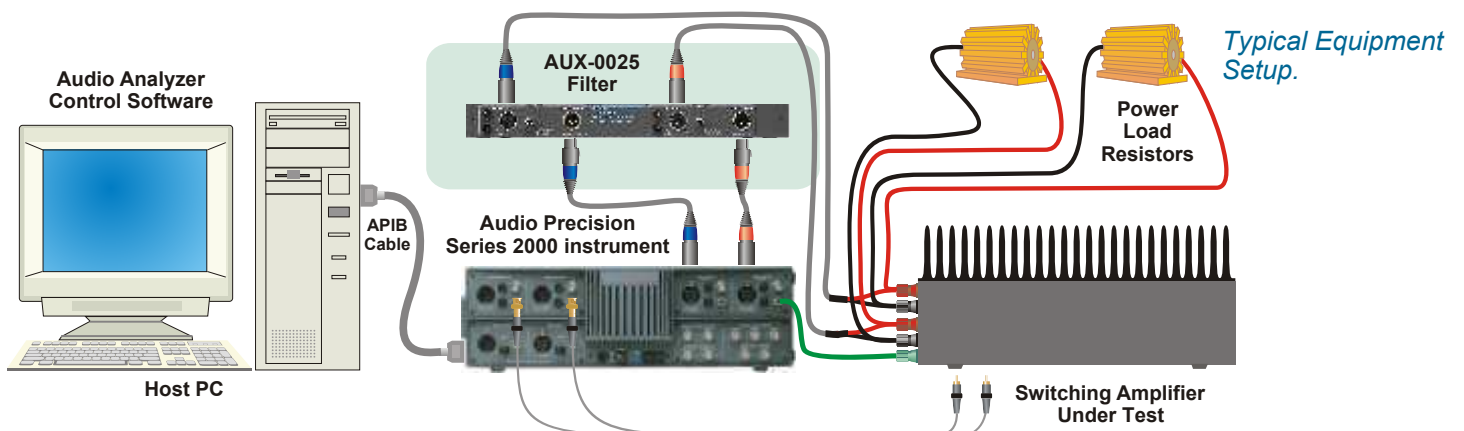
The solution to this problem is to precondition the signal before presentation to the analyzer. The way to do this is in the form of a low pass filter that will soften the fast edges while passing the primary audio signal intact. The best approach to this filter is a passive design, as it will handle

the fast edges properly, is relatively low cost, and will not require power. A well-designed passive filter will also not compromise the audio signal passing through it by adding noise or distortion as an active design might.

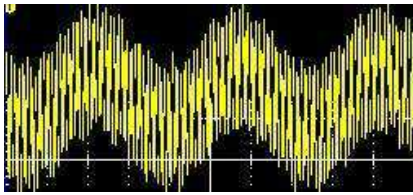
A passive design is also necessary to handle the wide dynamic range of signals that are normally presented to an analyzer. Any active filter has a limited amplitude range of operation. Thus, an active design would require an input attenuator and variable gain to accommodate the wide range of possible signal levels to be analyzed. Including such capability in an active design would be virtually duplicating the front end of the analyzer, an impractical approach from both cost and application points of view.

The Audio Precision **AUX-0025 Switching Amplifier Measurement Filter** is a dual channel multi-pole LRC passive filter that provides the necessary attenuation of out-of-band signals and reduces the steepness of the fast switching edges.

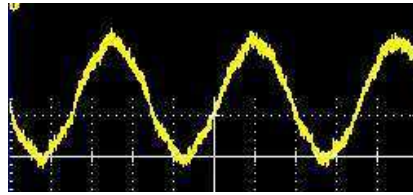
The AUX-0025 is a two-channel device that can be used with balanced or unbalanced amplifiers or analyzers. The input connectors replicate the input connectors found on Audio Precision analyzers: XLR female jacks and banana jacks. The output connectors are XLR male plugs. Since loading capacitance is of concern, two short XLR male to XLR female cables are included to facilitate connection to the analyzer. For convenience, these cables are color-coded.



Examples of switching amplifier output signals



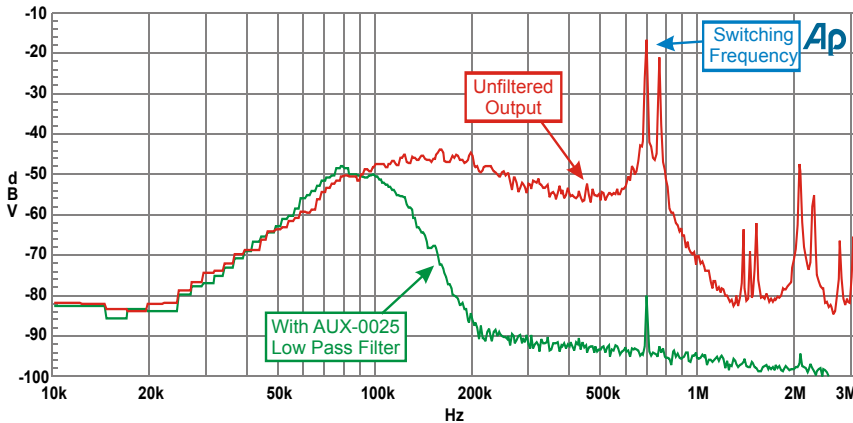
Unfiltered output from switching power amplifier.



Filtered by AUX-0025.

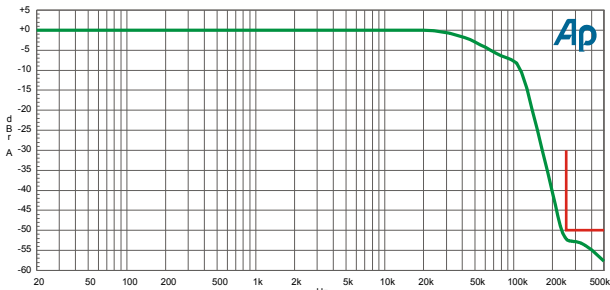
The time-domain oscilloscope traces above illustrate the effect the filter has on the unfiltered output of a typical switching amplifier. The photo on the left shows a signal from a switching amplifier. The photo on the right shows the same signal at the output of the amplifier filtered by the AUX-0025

low-pass filter, which attenuates the out-of-band frequencies to permit distortion, noise and other performance measurements. Notice how the unfiltered signal masks other components modifying the sine wave, affecting the capability of an analyzer to properly characterize the performance of the amplifier.

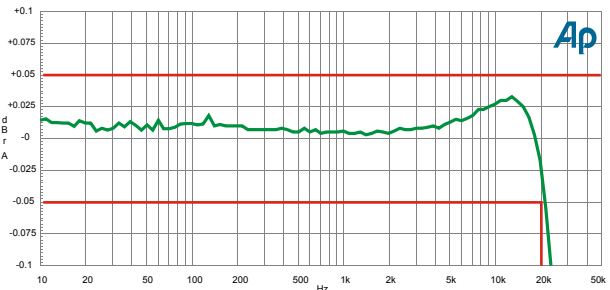


Spectrum analysis of the output of an amplifier with and without the AUX-0025 filter. The red trace shows the unfiltered output; the green trace shows the effect of adding the filter.

Filter Response Characteristics



Response showing attenuation beyond the audio band.



Pass-band response showing flatness out to 20 kHz.

Specifications

Frequency Response: ± 0.05 dB, 10 Hz to 20 kHz.

Insertion loss: typically 0.05 dB.

High Frequency Rejection: typically >50 dB, 250 kHz to 20 MHz.

Maximum Input: ± 200 V_{peak}.

Interchannel Crosstalk: >90 dB at 20 kHz.

Distortion:

- < -110 dB harmonic (measured at 70 V_{pp}, 1 kHz).
- < -100 dB IMD (at 70 V_{pp} with 18 kHz and 20 kHz dual tone test signal. IMD components are at 2 kHz, 16 kHz, and 22 kHz).



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