Achieving Excellent Audio Performance in Digitally Controlled Pots

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Recently, Intersil embarked on a campaign to inform the multimedia and home consumer entertainment communities about the excellent audio characteristics and ease of use of Intersil's Digitally Controlled Potentiometers (XDCPs™). To prove this claim, a standard XDCP was subjected to a battery of tests. The following testing parameters were chosen:

Signal to Noise Ratio (SNR)—the ratio of the normal operating level of the device compared with the device's baseline noise floor. SNR can be thought of as the effective dynamic range of most types of analog audio devices. The higher the SNR number, the better. SNRs exceeding 120dB are now necessary for today's low-noise, digital stereo and six-channel home theater audio entertainment systems. Another good rule of thumb for SNR is to put the Device Under Test (DUT) into a very low noise/quiet audio playback system. Then turn the DUT up to full volume, without any input signal, and listen for any increase in broadband noise at the playback output transducer (speaker/headphones).

Total Harmonic Distortion + Noise (THD+N)—measured by attenuating the fundamental signal (1 kHz @ 0dB) with a narrow-band notch filter, then measuring the remaining signals, which consist of harmonics of various order, wide-band noise, and possibly interfering signals. THD+N causes audio signals to become smeared and less clear. It can also raise baseline noise levels, which tend to mask out low level audio information. Creating extra signals and adding them back into the final output is always a BAD thing.

Frequency Response—where an audio sine wave signal is generated to sweep across the frequency range of 20 Hz to 20 kHz and is then applied to the input of the DCP. The output signal of the DCP is then measured for any amplitude variations. In a good device the output signal level will not vary more than ± .1 dB over the entire measurement frequency range. Variations in frequency response can cause audio signals to sound "dull and muted" or "bright and edgy."

A Two Tone Harmonic Test (18 + 19 kHz) takes two zero dB sine wave signals at a selected frequency spacing and feeds them into the DCP. The DCP output is then measured across the entire audible audio range (20 Hz to 20 kHz) to see if any signals appear that are the results of the addition and subtraction of the two original signals (harmonics). Figure 1 shows sample test results and the test setup. This test is useful in revealing audio frequency anomalies, which can be created by bad layout, non-linear responses, stray capacitance, and other circuit abnormalities.

Stepping Noise (must be below audibility)—A high quality playback system is employed, along with a DCP as the main system volume control, to listen for any "clicking" or "burping" associated with level control adjustment. Noise audibility of any kind that is a result of changing the output signal level using the DCP is unacceptable.

Channel Separation—where a zero dB 1 kHz signal is inserted into one channel of a multichannel system and the other adjacent channel/channels are left floating. The floating channels are then measured for signal content. The level of the signals measured on the floating channels referenced to the 0dB 1 kHz signal channel is the "separation" specification number expressed in negative dB. The more negative the number, the better the circuit. A separation of 100 dB between left and right channels in any audio type of equipment is a good number.

Results of tests on an X9408 XDCP

1. Signal to Noise Ratio (SNR):-127dB
2. Total Harmonic Distortion + Noise (THD+N): -117dB
3. Frequency Response 20 Hz to 20 kHz:±.05dB
4. Two Tone Harmonic Test (18 + 19 kHz): (see graph)
5. Channel Separation (chan 1 to 3 on the 9408):-100dB
6. Stepping Noise: inaudible

The results of these tests indicate that XDCPs are well-suited to applications that require low-distortion audio signal level control. Furthermore, with their simple serial interface, XDCPs are easy to implement, making them the level control part of choice for the next century.

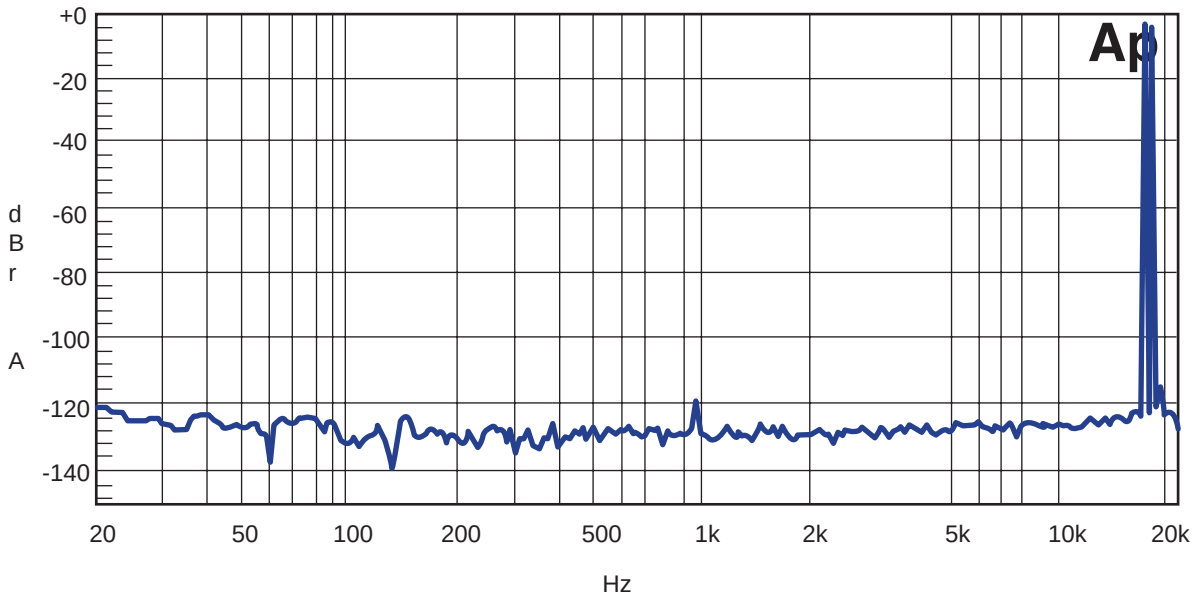

FIGURE 1A. AN AUDIO PRECISION 2 (AP2) GRAPH OF A TWO TONE (18+19 kHZ) MEASUREMENT MADE WITH A INTERSIL X9408 DCP

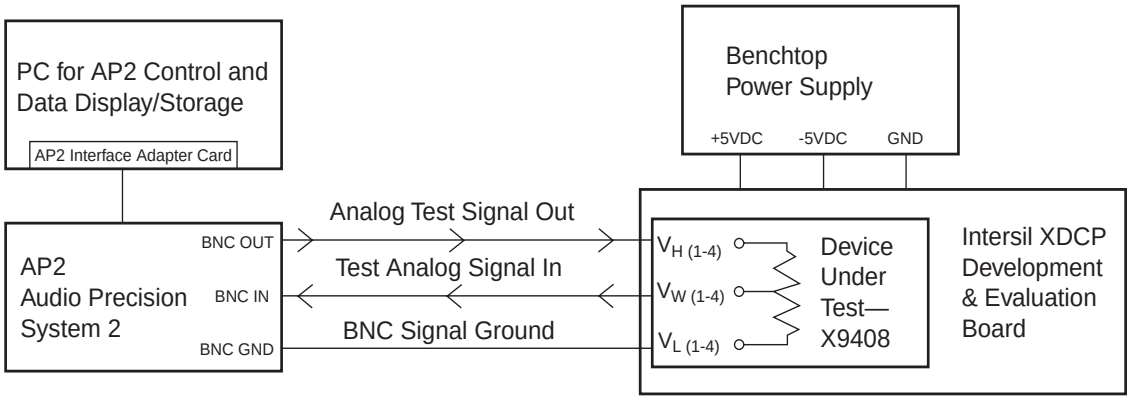

FIGURE 1B. AUDIO MEASUREMENT TEST SETUP

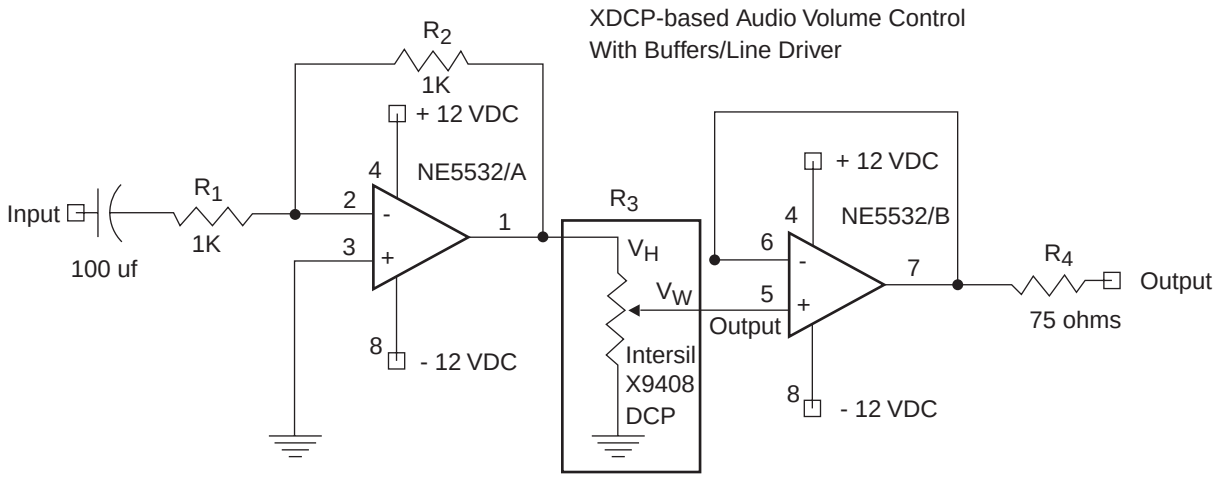

FIGURE 2. EXAMPLE APPLICATION OF A INTERSIL XDCP USED AS A VOLUME CONTROL