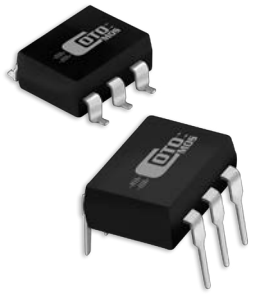
OUTPUT MUTING IN HEADPHONE AMPLIFIERS & PORTABLE SPEAKERS

WITH NEGLIGIBLE HARMONIC DISTORTION USING COTOMOS® RELAYS



Headphones and speakers are designed to be fed only AC signals. A DC signal applied to headphones and speakers produces an initial "pop," after which actual damage can result depending on length of time the DC is applied and the voltage level. DC signals can show up at an amplifier output during the turn-on and turn-off periods while the power rails are going up/down. For this reason the output of audio amplifiers are often muted for a second or two during start-up. DC can also appear at the output due to a failure of an amplifier output stage transistor or IC.

To prevent this problem, headphone amplifiers often have mechanical relays (between the amplifier output and headphones or speakers) designed to disconnect if DC appears on the amplifier output. While mechanical relays work, they have problems. The mechanical contacts eventually wear out, resulting in an increase in resistance and outright intermittent contacts. The relay coils draw significant current which becomes a source of battery drain in powered devices. In the case of a short in the amplifier output transistors, a high DC voltage can be present which produces a DC arc on the mechanical relay contacts that is hard to break.

Using mosfets as a muting & protection switch has historically been avoided by audio purists ("audiophiles") since the "on" resistance is large enough to affect the damping factor with lower impedance headphones. The damping factor issue is why audiophiles prize headphone amplifiers with nearly zero "output impedance", which is the resistance looking back into the output port of the amplifier. A muting circuit should not add any significant amount of output resistance to the amplifier. A large "on" resistance forms a voltage divider with the impedance of the headphones or speakers that also reduces power delivery.

The CotoMOS® CT128/CS128 relay is the perfect muting circuit solution. With an AC-wired, "on" resistance of just 50mΩ the relay won't make any significant change in amplifier damping factor or power delivery, even using 16 ohm headphones or IEMs. When the CotoMOS® relay is AC-wired it is polarity independent -t an important feature since the amplifier output goes through zero-crossings with respect to ground. The miserly 3 mA of relay LED current for fully "on" MOSFETs in the device is very battery friendly for portable headphone amplifiers and speakers.

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Several control circuits for the CotoMOS® relay are possible, depending upon the goal. For battery-powered headphone amplifiers, the goal may be merely to eliminate turn-on and turn-off pops caused by the power rails going up and down. Figure 1 shows a simple RC time delay circuit feeding a mosfet to delay turn-on until the power rails are stable in 1 or 2 seconds.

For output DC detection, a low-pass filter or integrator can be used on the amplifier output signal to extract and detect any DC present on the signal. This method directly senses DC present on the amplifier. One tradeoff in this type of circuit is the integration time. Several seconds may be needed to extract stable DC.

Two concerns that may occur over the use of CotoMOS® relays on the output of high- performance audio amplifiers are the amount of added harmonic distortion, and the level of output muting. The audio distortion analyzer graphs presented here show that the CotoMOS® CT128/CS128 relay produces only negligible distortion products - a THD level of around -2dBV. The measured muting level with a 32 ohm load is -70dBV.

Figure 2 shows the base loopback harmonic distortion of the tester. Figure 3 shows the harmonic distortion levels of a headphone amplifier based on a Texas Instruments OPA1688 chip into a 32 ohm load. Figure 4 shows the harmonic distortion level with the muting circuit in Figure 1 added to the output of the OPA1688 amplifier with the same 32 ohm load. Figure 5 shows the output muting level with a 32 ohm load.

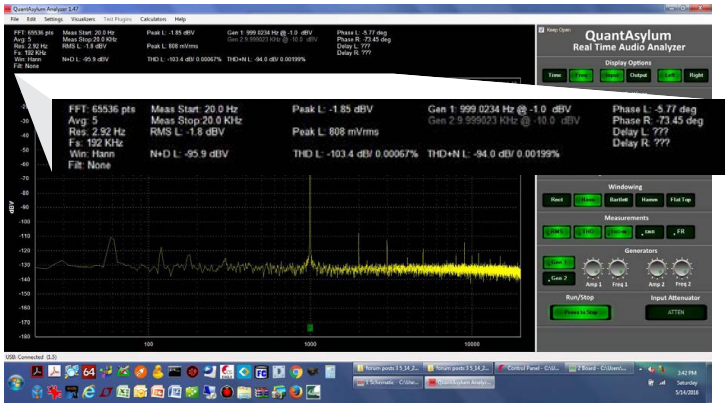

Fig. 1. SSR bypassed -1dBV input 1KHz with 22uF electrolytics

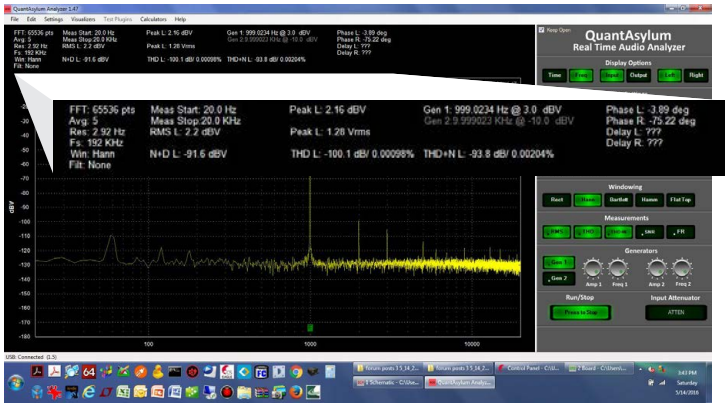

Fig. 2. SSR bypassed 3dBV input 1KHz with 22uF electrolytics

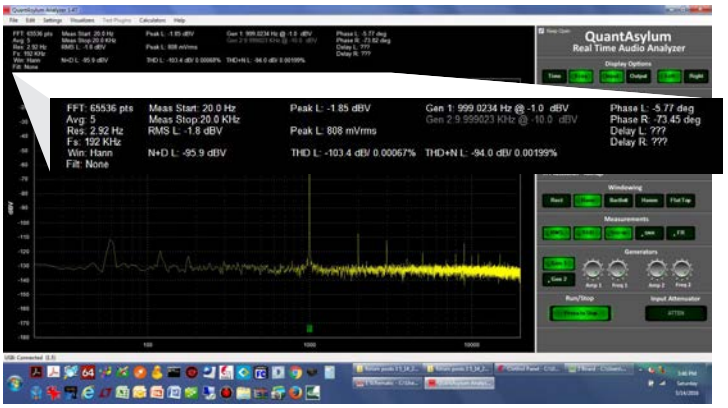

Fig. 3. SSR installed -1dBV input 1KHz with 22uF electrolytics

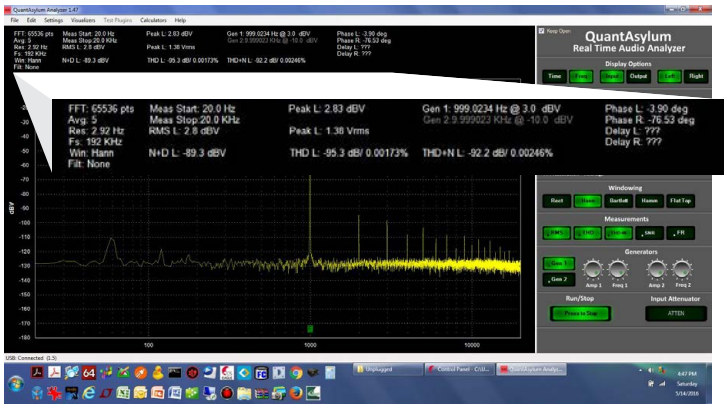

Fig. 4. SSR installed 3dBV input 1KHz with 1uF ceramics muting board installed

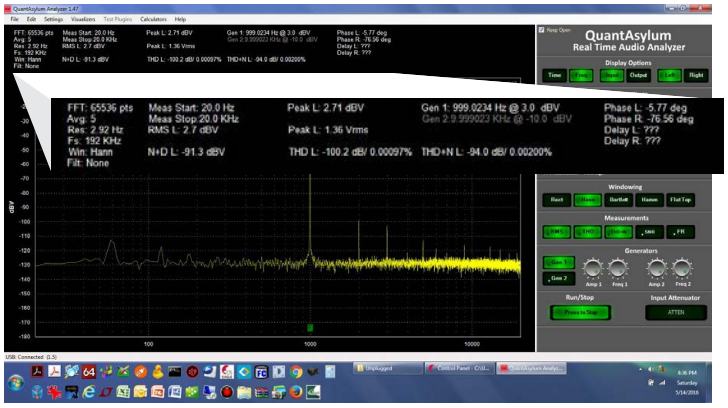

Fig. 5. SSR installed 3dBV input 1KHz with 22uF electrolytics muting board installed

To learn more about Coto Technology's CotoMOS® solid state relay offerings (including the CT128 / CS128 relay) and how our applications support team can help you with your latest design, please contact us at Cotomos@cotorelay.com or visit our website at www.cotorelay.com and hyperlink the email address and website.