PROTEK DEVICES
ANALOG PRODUCTS DIVISION

SHUNT Pop-Click noise Suppression IC for STB and MP3 player type applications

By Nihar Modi
Design/Applications Engineer

Introduction

Many home entertainment systems - Set-top boxes in particular - nowadays are designed with low power CODECS. Usual CODEC voltages range from 1.8V to 3.3V. In these circumstances the maximum audio swing available at the DAC output is about $1V_{rms}$ (max.). In order to increase the signal-noise ratio (SNR), system designers often drive this DAC output through an operational amplifier (opamp) (LM358) with a programmed gain. The amplifier will provide an output voltage swing of $>3V_{rms}$ which is considered good enough for an SNR of more than 84dB. In order to amplify the signal to 3Vrms, the opamp has to run at a single ended supply >9V. The DC voltage at the o/p of the opamp is around 1/2Vcc. A DC-blocking capacitor is placed at the o/p to get rid of the 1/2Vcc generated by the Opamp.

A similar theory applies to MP3 player type applications. However, the effect of POP noise is much more intense as the load is 32Ω and the series resistance in the o/p stage is very small. This difference in the two applications is shown in the typical application circuits later in this white paper.

The presence of a DC-blocking capacitor at the output stage of the opamp causes an audible noise to form during system start-up and shutdown. This noise is also known as pop-noise. The typical output stage is shown in figure1.

PA4220 is a low power (I_{CC}< 1µA) monolithic mixed signal device. PA4220's function is to control the power supply transition noise in audio systems. PA4220 boasts several features that make it a "one of a kind" product on the market. Most prominent is the feature is that it does not require any external signal to suppress POPUP and SHUTDOWN Noise.
PA4220 requires few external components for its operation, working from low to medium supply voltages of up to 5V. The ramp time of the supply should be greater than 50ms.
On power-up and power-down the output of the amplifier stage is switched to a convenient low impedance voltage rail hence muting the amplifiers, preventing the audible pop, which is normally heard in the headset or speakers.
PA4220 operates as a passive shunt device; hence there is minimum distortion (negligible). Most of the distortion at the o/p is generally due to amplifier characteristics. It has extremely low current consumption (<1uA). PA4220 is equipped with ESD (Human Body Model) protection circuitry on the outputs.

Features

- Extremely Low supply current (<1µA).
- Shunt operation hence distortion free.
- Instantaneous Power-up and Power-down muting.
- No external microcontroller signal needed.
- ESD protected outputs.
- 1.5V to 5V supply operation.
- Handle upto 3.5V RMS signal.
- Compact 2 x 2 x 0.8mm 6L DFN.
- Standard 8L SO-8 packages.

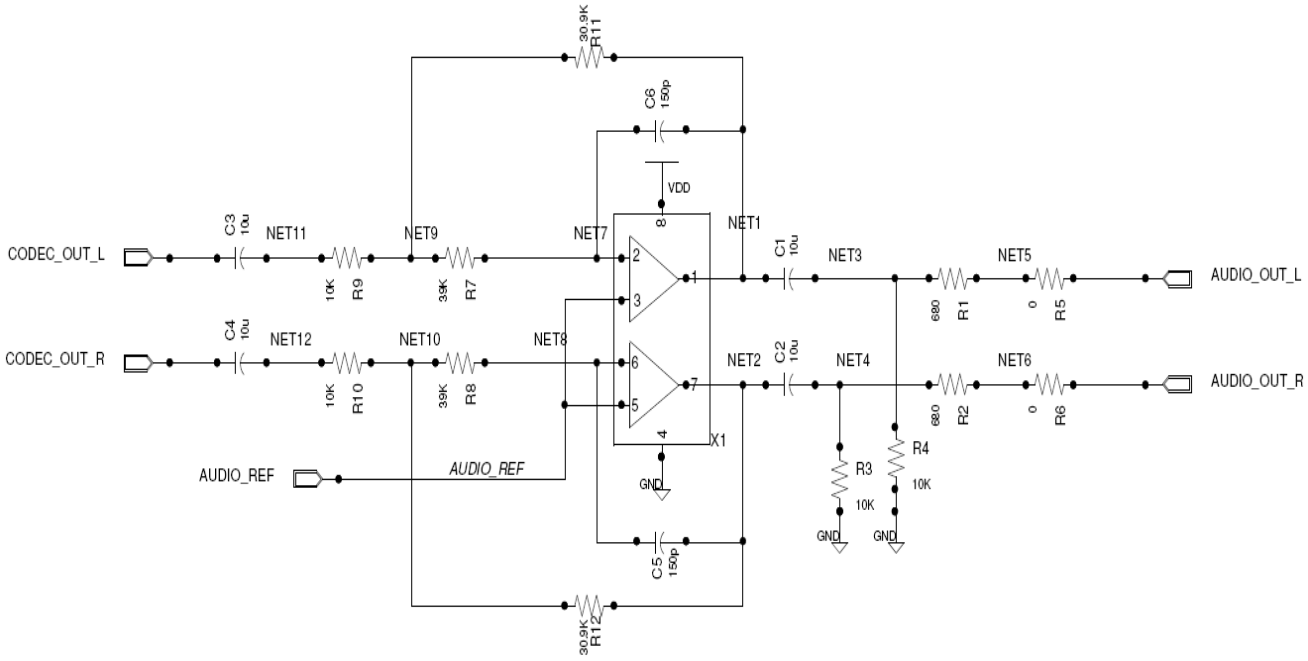

Figure1: Typical output stage of a set-top box

SYSTEM STARTUP

Switch Mode Power Supplies use by most of the system designers have a rise time of 50-200ms. During this time period all the system components are getting charged up. Due to the inrush of current the positive plate of the capacitor C1 and C2 in figure1 charge and discharge. This charging cycle produces an audible pop click noise.

This operation is shown in figure 3 using a 600Ω load. Channel 1 is the Vcc to the amplifier and channel 2 is the pop noise at the o/p.

SYSTEM SHUTDOWN

The reverse action takes place during shutdown. The capacitors C1 and C2 experience a discharge at their positive plate. The negative plate follows this action and hence this quick discharge is heard as audible click noise at the o/p.

This operation is shown in figure 4 using a 600Ω load. Channel 1 is the Vcc to the amplifier and channel 2 is the pop noise at the o/p.

SYSTEM STARTUP USING PA4220

PA4220 is a shunt device. It has two channel mute lines which are connected after resistors R1 and R2. This connection is shown in figure2. The PA4220 detects the power up and pulls the o/p stage to a low impedance stage and hence suppressing the pop noise. The time for which the o/p remains in the low impedance stage is determined by the capacitor C7 as shown in the figure2. 1uF capacitor would keep the o/p stage in low impedance stage for approximately 200ms. However this time could be varied by varying the C7 capacitor.

This operation is shown in figure 5. The PA4220 clearly suppresses the click noise Channel 1 is Vcc and Channel 2 is the pop noise at the o/p.

SYSTEM SHUTDOWN USING PA4220

The reverse action takes place during shutdown. PA4220 detects the power down and pulls the o/p stage into a low impedance stage suppressing the click noise. This action takes place due to the capacitor C8 connected at the CAP pin. The charge stored in the capacitor is used power on the internal driver stages to turn the internal switches ON. Larger the capacitor better would be the shutdown performance. 100uF -470uF is recommended value.

This operation is shown in figure 6. The PA4220 suppresses the click noise by 50%. This suppression is extremely application specific and is dependent on the power supply characteristics and the capacitor C8.

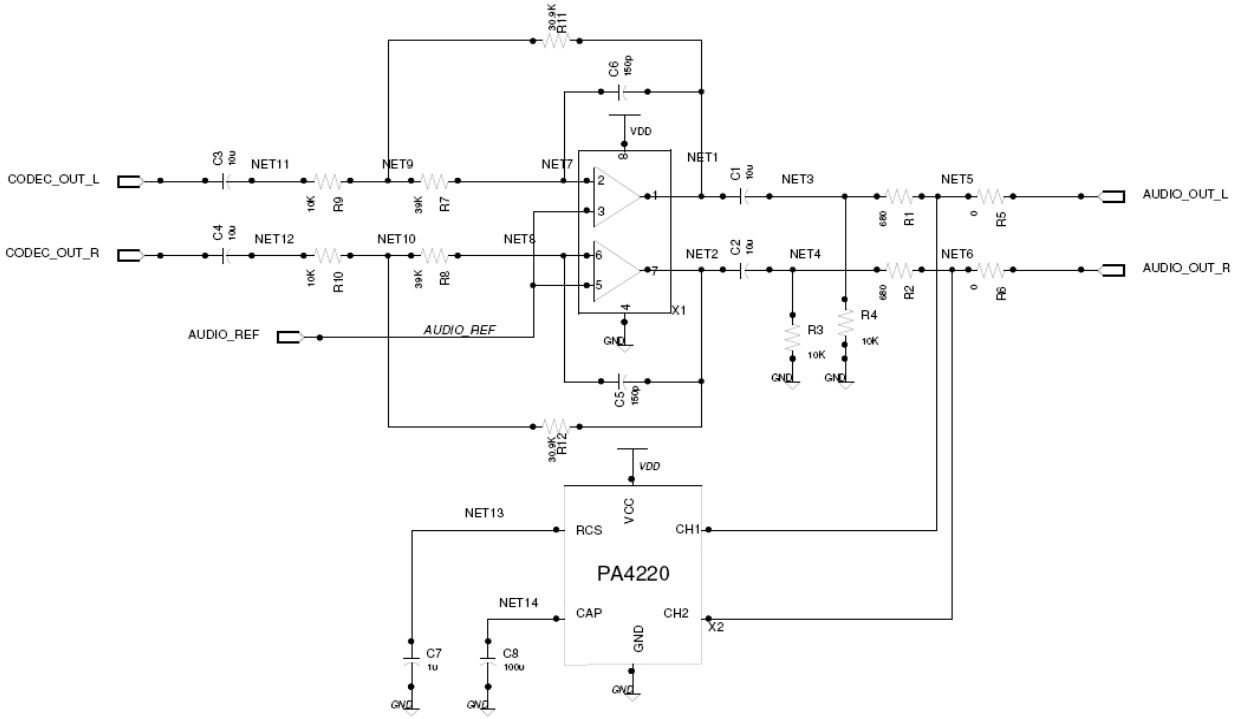

Figure2: Typical output stage of a set-top box with the PA4220

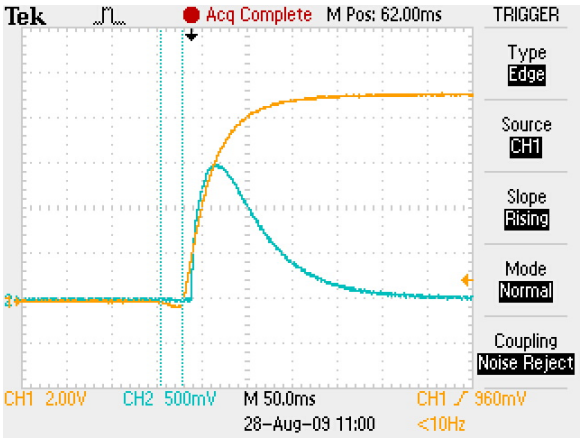

Figure3-StartUp pop noise using 600Ω load

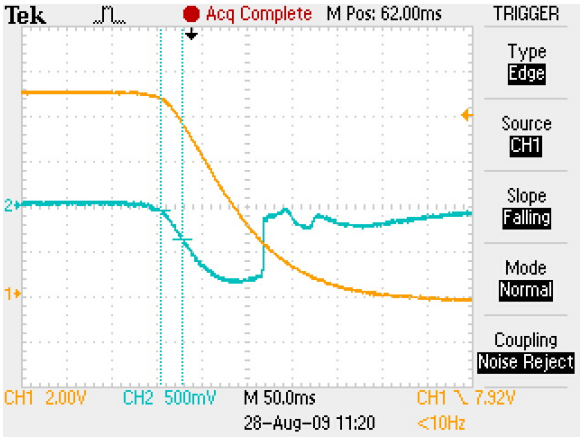

Figure4-ShutDown click noise using 600Ω load

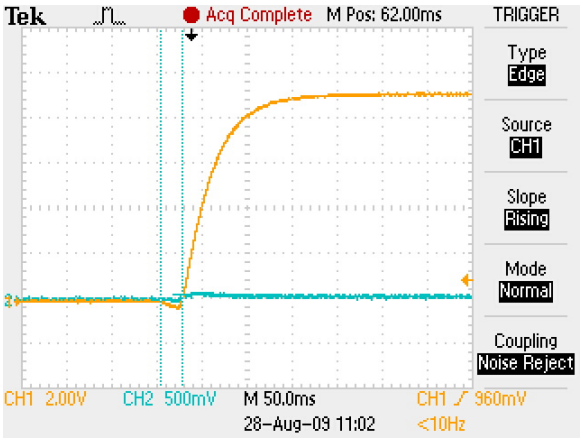

Figure5-StartUp pop noise suppressed using PA4220 on a 600Ω load

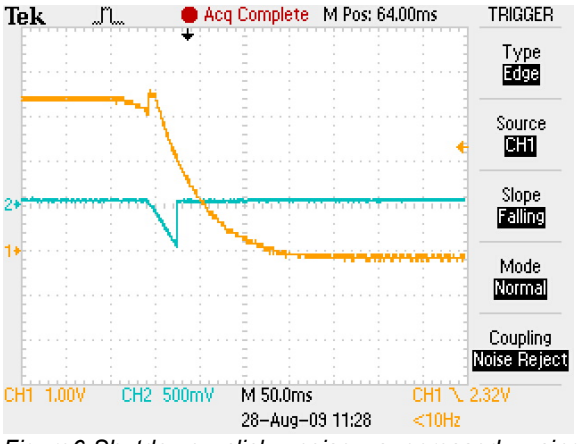

Figure6-Shutdown click noise suppressed using PA4220 on a 600Ω load

Design Considerations

System Design is the most crucial part when designing in the PA4220. Power Supply design plays an important role in defining the performance of PA4220. The ramp times of the power supply should not be too fast or too slow. Ideal power supply ramp times should be around 50ms. Power supply sequencing also helps enhancing the performance of PA4220, i.e. if the Vcc to the PA4220 turns ON approximately 20ms before the Vcc to the amplifier, suppression in pop noise would be considerable.

The choice of the external capacitor is purely one of convenience. The PA4220 works the same with an electrolytic or tantalum capacitor. The capacitor at the RCS pin gives the designer to choose the time for which o/p stage can be held at low impedance state during startup. The capacitor at the CAP pin helps holding charge during shutdown. This capacitor can be varied from 100uF to 470uF based on shutdown characteristics.

Conclusion

The PA4220 is a very efficient and cost effective component that can be used by system designers who employ an audio line driver using a single-ended power supply. Currently most system designers use a discrete solution which uses a lot of board space and can escalate the system costs too. The PA4220 can replace all of these components as it is a monolithic solution. It can easily handle a signal of >3Vrms without much distortion. It is available in a compact 2mm x 2mm x 0.8mm 6L DFN and a standard 8L SOIC package.

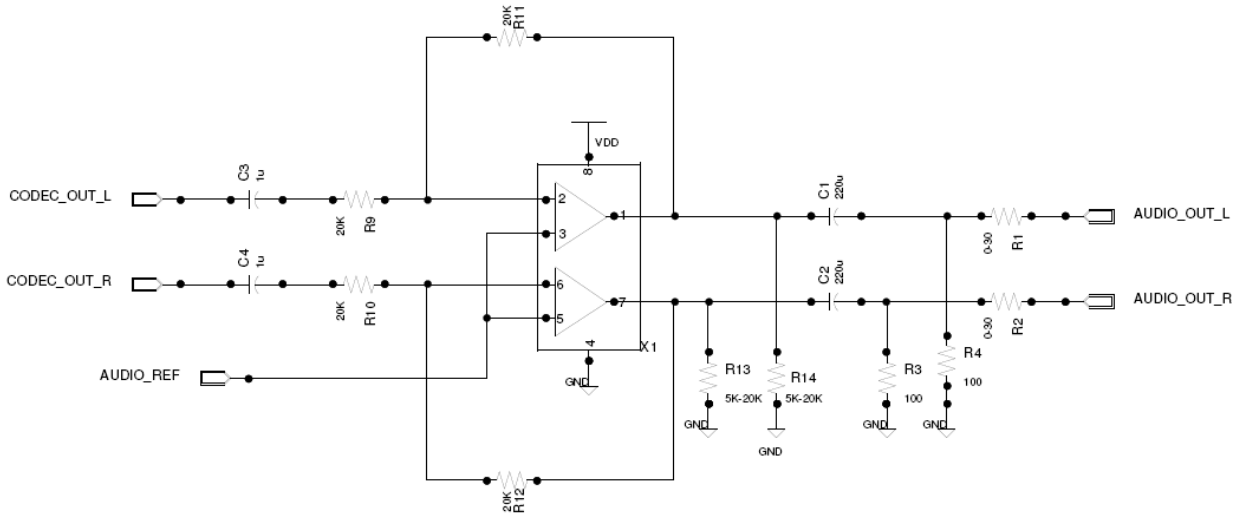

Figure7: Typical output stage of a MP3 type application

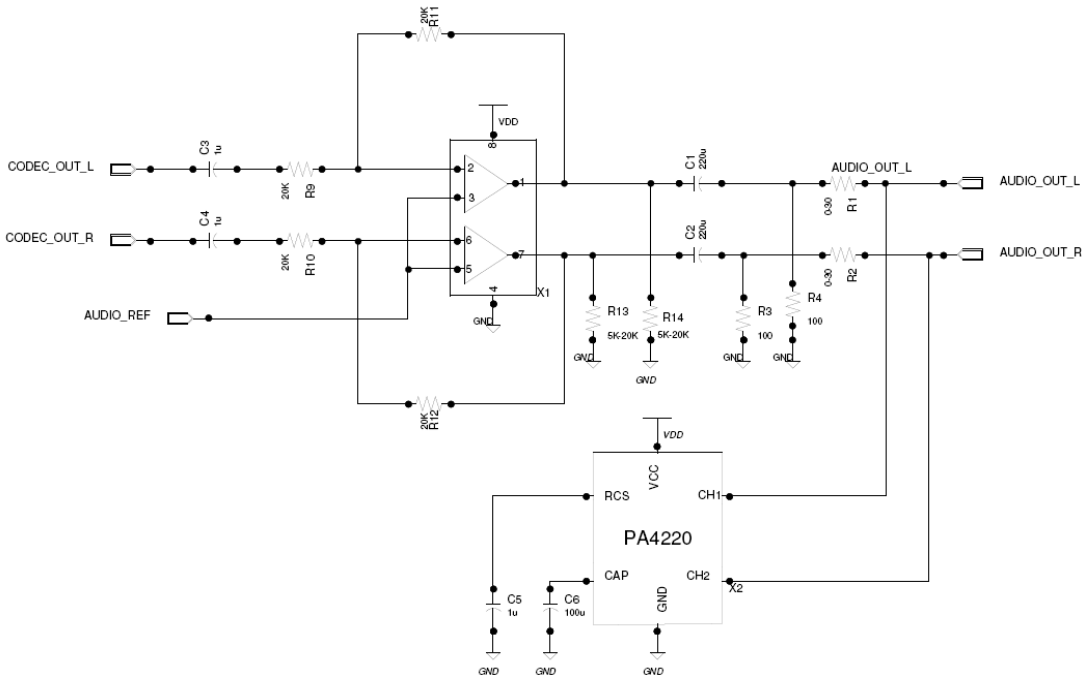

Figure8: Typical output stage of a MP3 type application with PA4220

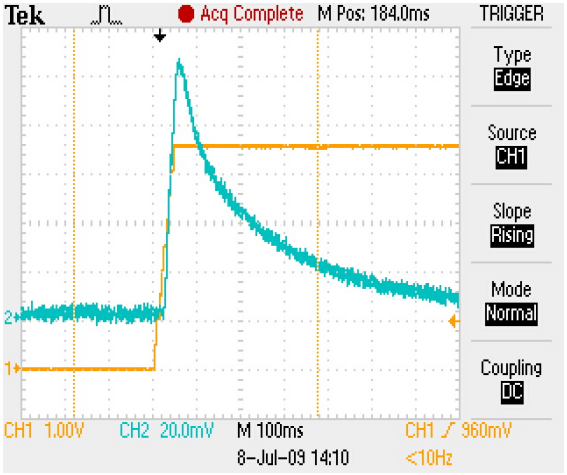

Figure9-StartUp pop noise using 32Ω load

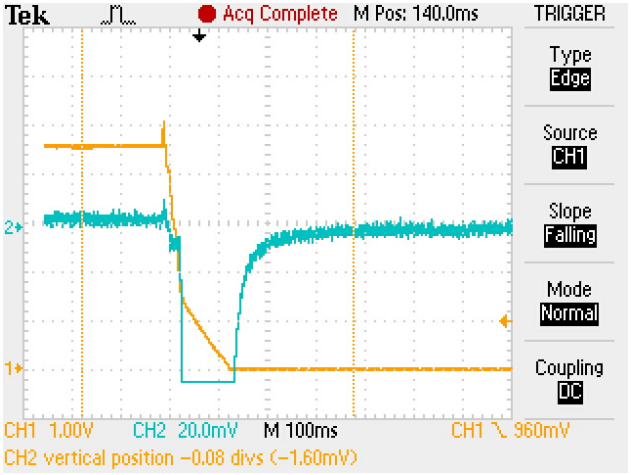

Figure10-Shutdown click noise using 32Ω load

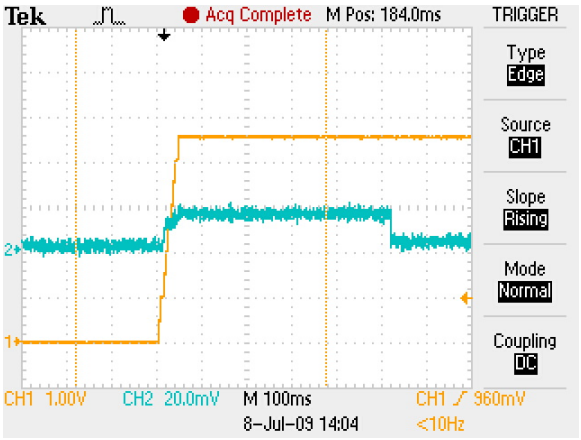

Figure11-StartUp pop noise suppressed using PA4220 on a 32Ω load

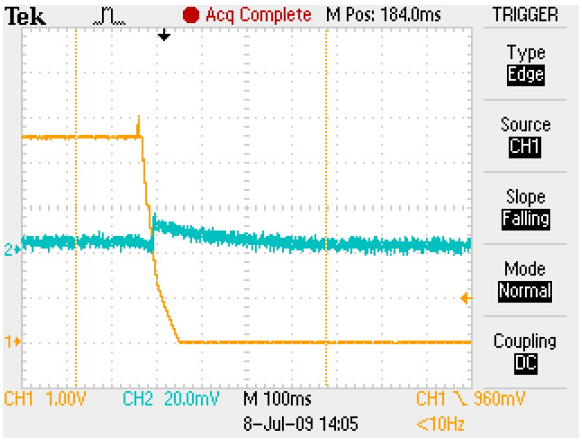

Figure12-Shutdown click noise suppressed using PA4220 on a 32Ω load