

# Click-Pop Noise Suppression IC improves system start-up and shutdown performance

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## Introduction

Many home entertainment systems - Set-top boxes (STBs) 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  $3V_{rms}$ , the opamp has to run at a single ended supply  $>9V$ .

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 shut-down. This noise is also known as pop-noise. The typical output stage is shown in figure 1.

PA4401 is the industry's first monolithic solution to suppress pop noise generated by such devices. The PA4401 can operate at VCC of either 9V or 12V. The PA4401 only requires ONE external component – a capacitor – to suppress the pop noise. The value of this external capacitor can control the turn-on time of the IC.

## Features

- 9V or 12V operation
- 3V RMS Capability
- Power-Up and Power-Down “POP” suppression
- ESD protected outputs
- 8-Lead SOIC/DFN package
- Only 1 external component required
- Series operation
- Low THD+N < 1% (600Ω load)
- Ron (On resistance): 0.8 Ω
- Ron Flatness: 0.4 Ω
- Total Harmonic Distortion: < 0.05%
- Current drain: < 5mA
- Load: 600Ω

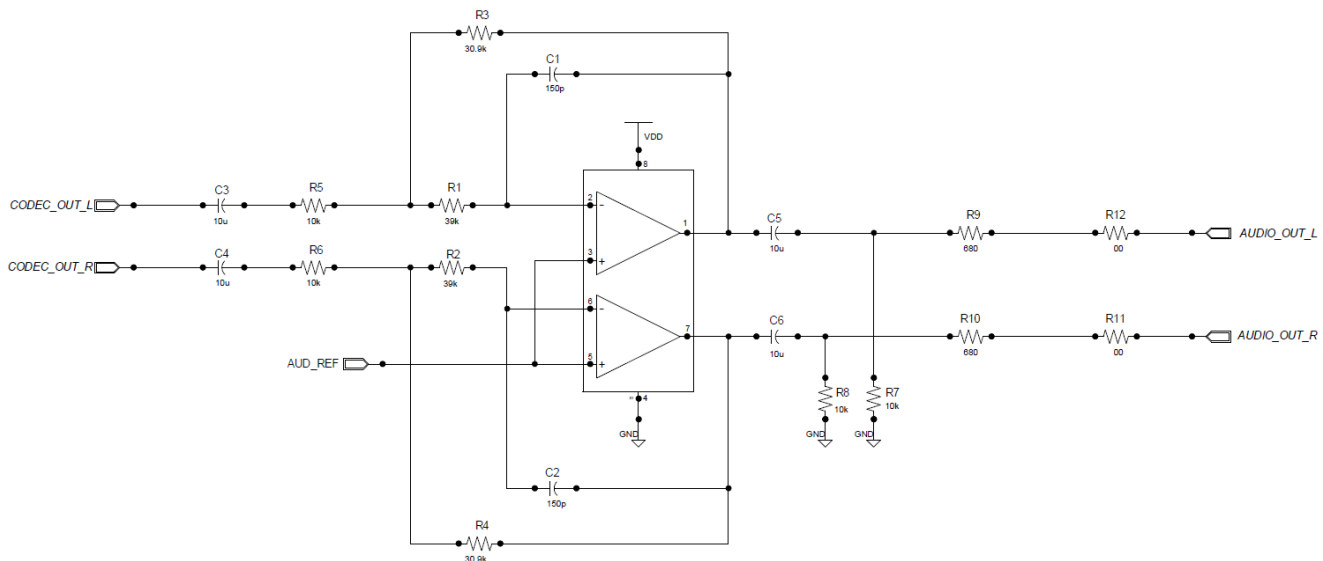


Figure 1: Typical output stage of a set-top box

### System Startup

Switch-Mode Power Supplies (SMPS) utilized by most system designers have a ramp time of about 50—200 ms during start-up. In this phase the different components of the system (in this case, the STB) are getting charged. Due to the inrush current experienced at the positive plates of the DC blocking capacitors C5 and C6 from figure 1 above, the output plates will charge and discharge. This charging cycle produces an audible pop-noise which when run through an amplifier (TV/Home Theater).

This operation is shown in figure 3. Channel 1 shows the power supply to the system starting up. Channel 2 shows the pop-noise that is seen at the 600Ω load.

### System Shutdown

When the system is in shutdown the reverse happens. The capacitors C5 and C6 experience a discharge at their positive plates. The negative plates follow suit and this cycle causes another audible pop noise to go through to the amplifier.

This operation is shown in figure 4. Channel 1 shows the power supply to the system starting up. Channel 2 shows the pop-noise that is seen at the 600Ω load.

### System Startup with PA4401

The PA4401 is placed right after the amplifier and before the DC blocking capacitors. It runs off of the same supply as the amplifier. This connection is shown in figure 2. During system start-up the PA4401 detects the power-on and smoothes out the startup waveform. This causes the capacitors C5 and C6 to charge slowly. Pop noise is thus reduced. The PA4401 gives some freedom to the system designer in selecting the startup delay to tackle the pop noise. The startup delay can be varied by choosing various values of the capacitor at C7. A 1μF capacitor should suffice for most applications. The startup operation with PA4401 is shown in figure 5. Channel 1 shows the power supply to the system starting up. Channel 2 shows the

### System Shutdown with PA4401

During Shutdown, the reverse process happens. The PA4401 detects a “power fail” condition and the control switches provide a slow discharge path for the +ve plate for the bypass capacitor to ground. At the same time the audio lines are “muted” to prevent unwanted signals from passing through. This shutdown operation is shown in figure 6. Channel 1 shows the power supply to the system starting up. Channel 2 shows the pop-noise that is seen at the 600Ω load.

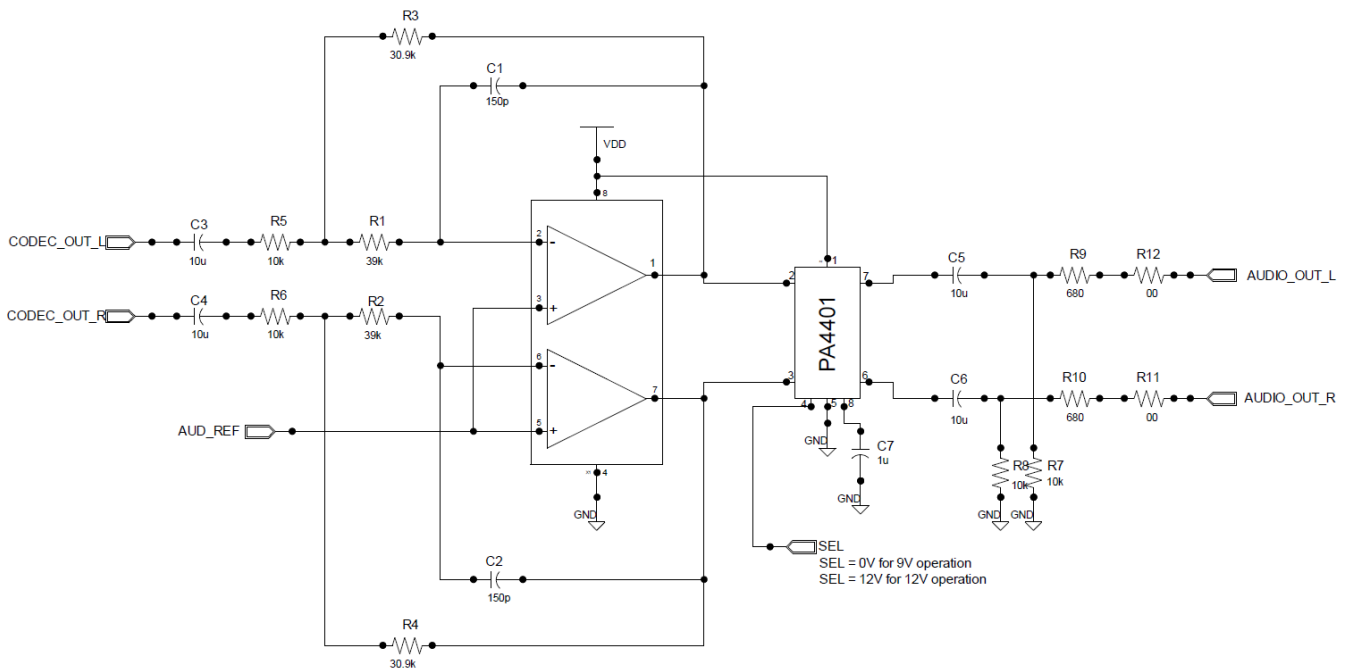


Figure 2: Output stage of a set-top box with the PA4401 Pop-Noise Suppressor

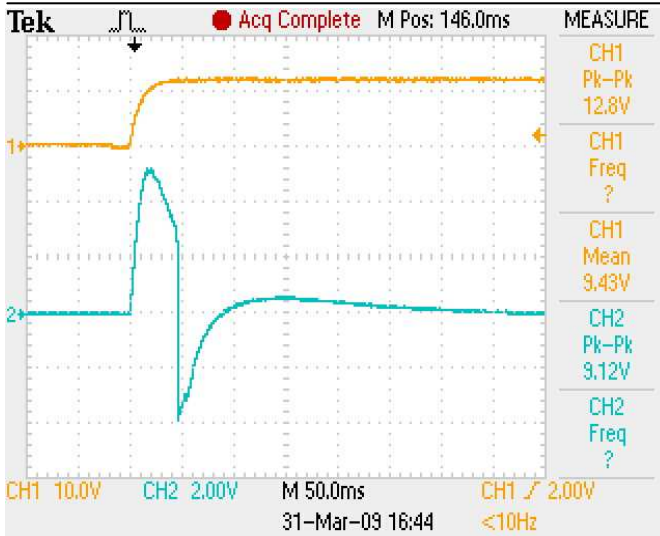


Figure 3: Start-up pop noise seen at 600Ω load

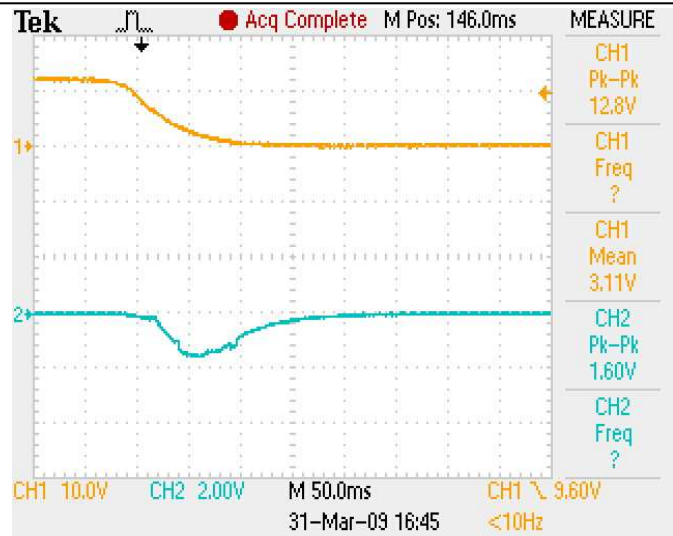


Figure 4: Shut Down pop noise seen at 600Ω load

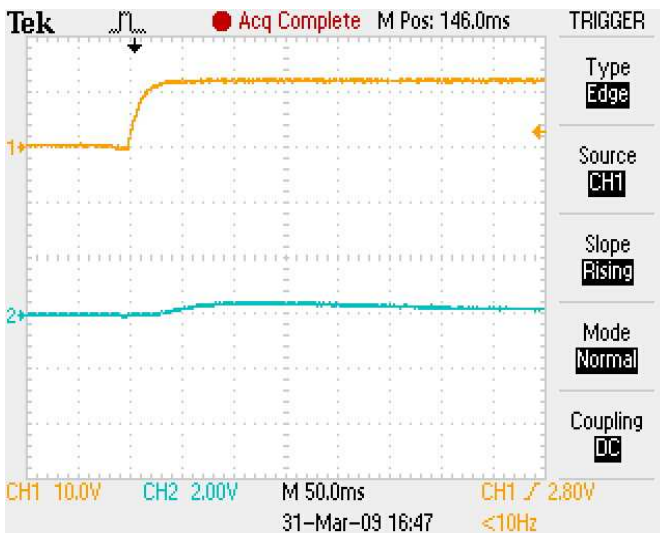


Figure 5: Start-up with PA4401 in circuit, seen at 600Ω load

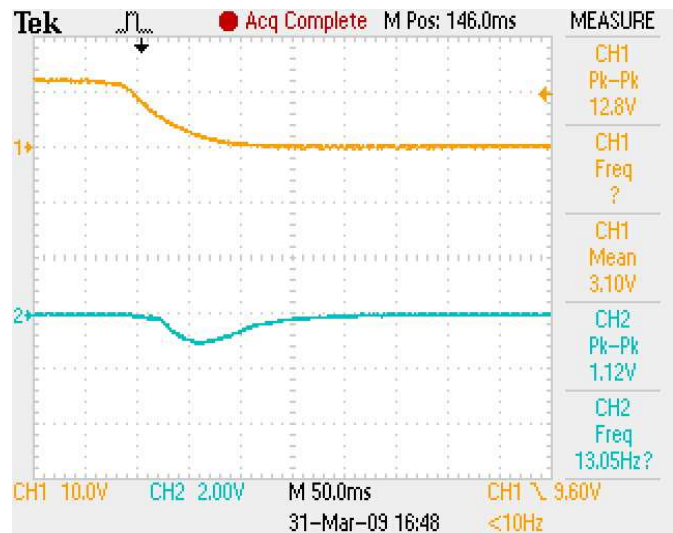


Figure 6: Shut down with PA4401 in circuit, seen at 600Ω

### Design Considerations

The PA4401 is designed such that the stereo lines can go “right through” it. Hence the board designer only needs to make space for the chip along his already existing signal lines. Care must be taken to make sure that there are adequate power supply bypass capacitors. A smooth transitioning SMPS will ensure that the PA4401 will work most effectively.

The choice of the external capacitor is purely one of convenience. The PA4401 works the same with an electrolytic or tantalum capacitor. It is recommended that the capacitor be at least rated for 30V. Using a 1μF capacitor will yield turn-on time of about 300ms.

turn-on time is sufficient to address the start-up characteristics of most commercial SMPS units.

### Conclusion

The PA4401 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 PA4401 can replace all of these components as it is a monolithic solution. It can easily handle a signal of >3V<sub>rms</sub> without much distortion. It is available in a compact 3mm x 3mm 8-Lead DFN or a standard 8-Lead SOIC package.