

### Pop Up Noise suppression using analog switches

Due to the standard method of AC coupling in audio systems there is a real possibility of the phenomenon "Pop Up noise" when switching audio signals.

The audible pop is a result of the capacitive charge/discharge characteristics of the AC coupling (DC Blocking) capacitor and the inductive speaker coil's response to these changes.

The voltage change across the capacitor is given by the equation:  $I = C (dv/dt)$

The equation indicates that with a sudden change in voltage there is a proportional increase in current through the capacitor. For steady state operation the amplitude from the amplifier varies slowly and the current through the capacitor to the speaker coil is fairly constant.

Because a speaker is a basic inductive coil, the equation used to describe inductive behavior is  $V = L (di/dt)$

This states that changes in current result in proportional changes in voltage across the inductor. This is due to the stored magnetic field in the inductor. The coil acts as a solenoid, which moves the speaker cone in and out. This movement produces the sound waves.

The two equations provide the explanation that for a sudden change in voltage across the capacitor produces a current spike that is fed into the speaker coil (inductor) causing a sudden movement of the cone providing an audible "pop" to the human ear.

A traditional  $\frac{1}{2}V_{CC}$  biased audio amplifier requires an AC-coupled capacitor to remove the DC content of the signal

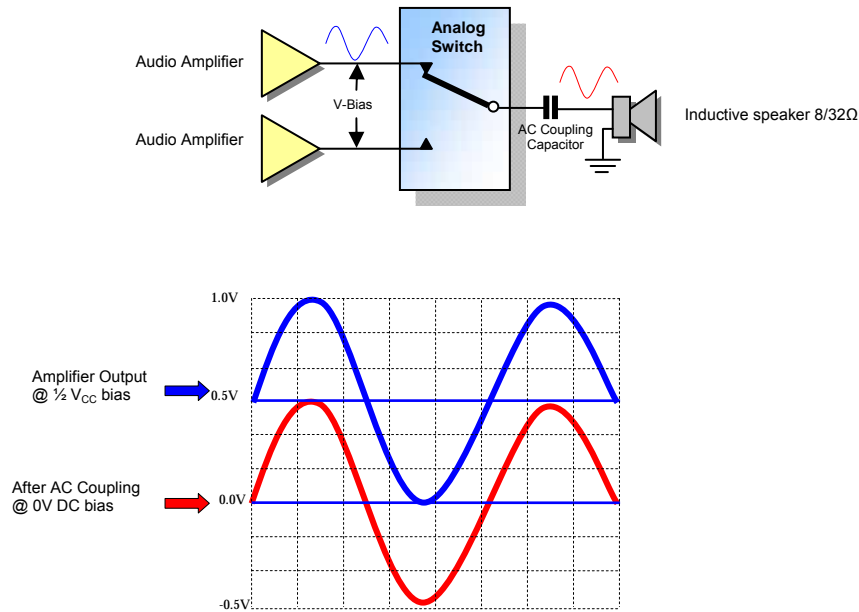


Figure 1. Traditional AC coupled Audio application (showing bias shift)

The application shown in fig.1 is fairly common for sharing multiple audio sources through one common speaker. Changing between the Audio sources can produce a sudden change in voltage across the AC-coupling capacitor producing a "pop" noise.

### Different approaches using Analog Switches to minimize the “pop”

Because capacitance is the root cause of the “pop” eliminating the need for an AC-coupling capacitor eliminates the primary source of noise. An AC-coupling capacitor is typically in the order of 100 -220 $\mu$ F. By transitioning to negative-swing-capable audio systems the coupling capacitor can be removed.

In addition to using negative-swing-capable analog switches, some analog switches have built in termination resistors on unselected outputs, which decrease the possibility of “pop” noise.

#### Terminate unused ports to ground.

A method to reduce “pop” noise is to terminate the unused ports to ground by means of termination resistors. This enhances the noise suppression characteristics of the switches by ensuring that any charge build-up is dissipated before the line is connected to the speaker.

When a single amplifier is driving multiple speakers it ensures that the unselected speaker output is held at ground so there is no sudden change in the audio path when the switch is toggled.

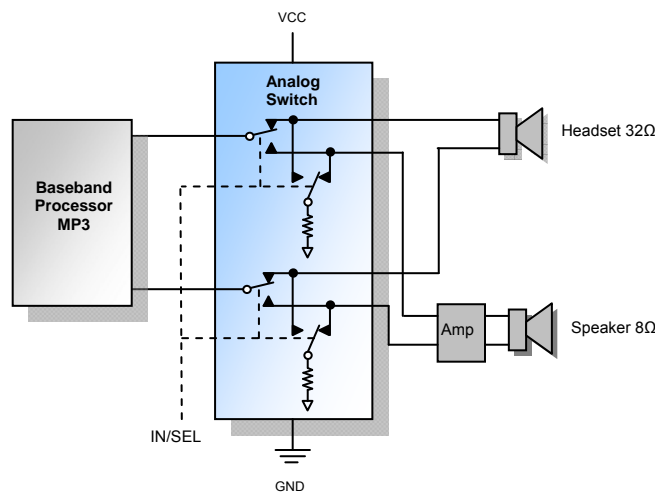


Figure 3. Analog switch with termination resistors

#### Control turn on rate.

An additional method of controlling “pop” noise is to slow down the charging rate of the decoupling capacitor. This reduces the effective ‘ $dv/dt$ ’ seen by the line capacitance. By lengthening the ‘ $dt$ ’ the change in current seen by the speaker is minimized thereby reducing the possibility of “pop” noise.

The PA4401 and PA4220 have been designed to do just this. It slows down the charging rate, at switch-on of the power amplifier, of the decoupling capacitor thereby removing the large pop that is normally heard.

The operation of the PA4401 and PA4220 is described in detail in separate documentation found on Protek Analog website.