Basic Layout Tips Part 2
Bypassing and Passive Components

Power Supply Bypassing

Bypassing digital audio data converters is a critical step for maximizing dynamic performance. This step can be executed by understanding a few basic do's and don'ts. The basic definition of a bypass capacitor is that it is used to conduct AC components in the power supply line around the data converter circuit. This AC component is removed from the DC supply, enabling the converter to achieve its stated performance specification. Failure to adequately remove AC noise from the power supply line will allow the noise to couple into the converter, resulting is dynamic performance reduction.

All AKM converters require at least two capacitors for bypassing: a large cap (nominally 10uF) for low frequencies, and a small cap (nominally 0.1uF) for high frequencies. The actual value of the capacitors depends upon the noise characteristics of the power supply. If the noise is predominately low frequency, increase the value of the large capacitor. If the noise is predominately high frequency, add an additional capacitor with a smaller value than the previously selected small capacitor. For AKM converters, VCOM is also bypassed. Depending upon the converter architecture, the range of the large capacitor may be from 2.2uF to 47uF. Refer to the product datasheet "System Design" diagram for the recommended values.

Placement of the capacitor near the converter is very important. For AKM converters, the bypass capacitors provide high speed current for the modulator operation. At a 48kHz sampling rate, the modulator runs at speeds of 64fs (3.072MHz) or 128fs (6.144MHz), so the bypass capacitors are actually used to store charge for this high speed current draw. Figure 1 is the recommended application circuit for the AK4396, where the bypass capacitors are connected between both the analog and digital supplies and their respective ground planes. These diagrams are usually located near the end of AKM datasheets, and are referred to as "System Design".

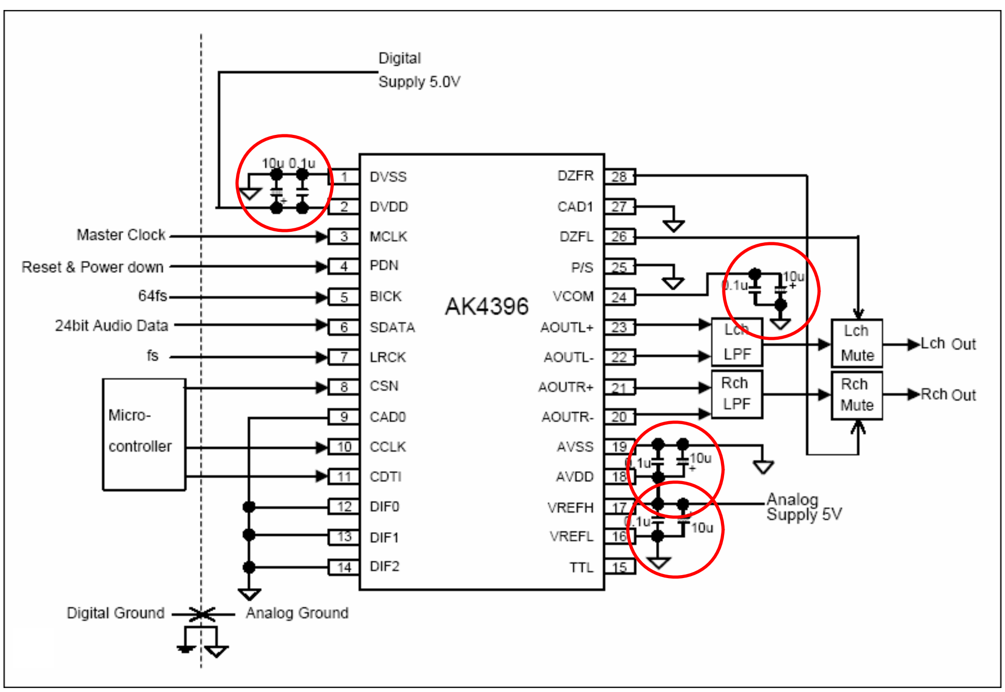

Figure 1. AK4396 Recommended Application Circuit

Note in the diagram that the high-frequency bypass capacitor is drawn closest to the converter. This placement should also be done in practice. The smaller cap should be closest to the power pin of the converter.

Placement of bypass capacitors

Placement of the capacitors is critical. Keeping in mind that the capacitors are used to provide high speed current for the modulator, it is very important to locate the capacitors as close to the power pin as possible, and avoid lengthy traces and vias. The capacitors need to be placed between the power source and the converter. Using vias and long traces reduce the benefits of the bypass capacitors and will degrade performance. Figure 2 is an example of "how not to do it". In this example, the current is available at the pins, but the bypass capacitors are reached through long traces and vias. In this case, there is virtually no benefit from the capacitors, as there is no current flow from the capacitors to the converter. The long traces and vias also act as inductors, and they will degrade performance.

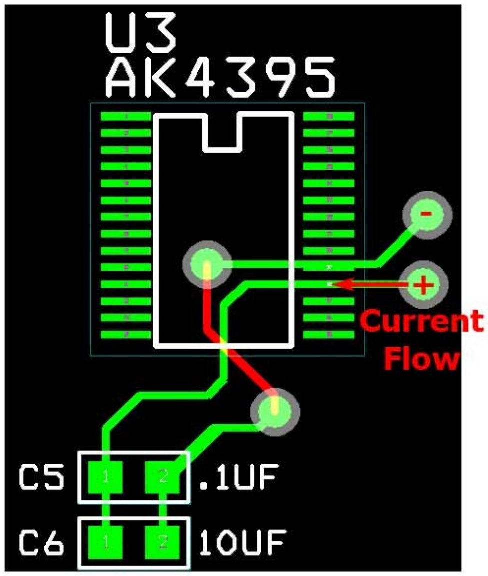

Figure 2. "How not to do it" 1: capacitors connected through vias

In figure 3, no vias are used, but the same problem occurs as when using vias. There is very little current flow from the capacitor to the power pin of the converter. This case is slightly better than the via case, but still should be avoided.

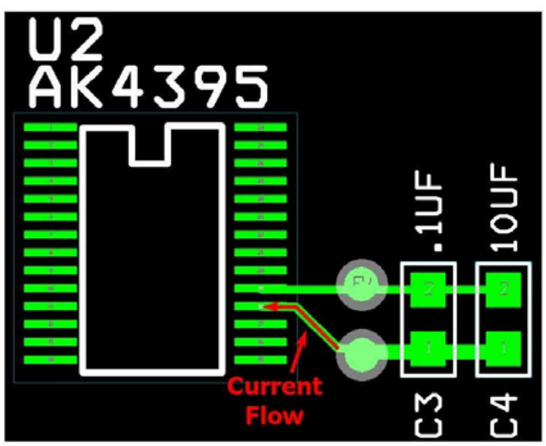

Figure 3. "How not to do it" 2: capacitors connected in parallel with the power source

The correct way to bypass an AKM converter is by placing the capacitors between the power source and the power pin, as close as possible to the pin. To achieve maximum benefit, it is strongly recommended that the capacitors reside on the same plane as the converter. Figure 4 is an example of proper placement of the capacitors, with current forced to flow through the capacitor to the converter's power pin.

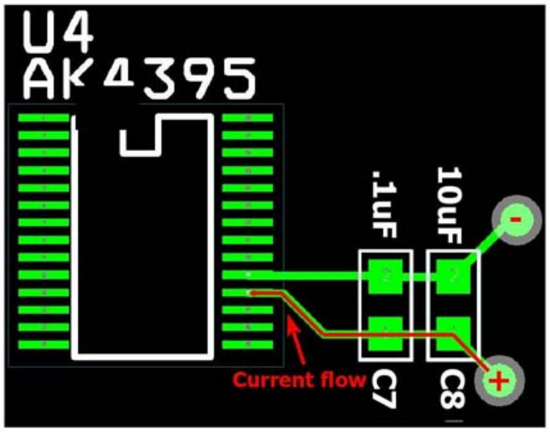

Figure 4. Proper placement of bypass capacitors

Passive Component Selection

Selection of passive components can have a profound effect on both sound quality and specification realization. Care must be taken to match the types of passive components with the end product objective.

Capacitors

For power supply bypass capacitors and DC-blocking, we recommend using aluminum electrolytics. These capacitors open when they fail, which will prevent catastrophic system failures. However, at low temperature, some low-grade electrolytic capacitors degrade in capacitance, resulting in high distortion. Tantalum capacitors should be avoided for bypassing, since they short when they fail. For filter capacitors that are in line with the audio signals, polypropylene film capacitors provide the best THD performance. For filter capacitors, be cautious of ceramics, which can induce piezoelectric effects into the system. This results in the board acting as a microphone for mechanical disturbances and vibrations.

Resistors

There are two types of resistors to consider: carbon and metal film. Each type has its advantages, depending on the primary objectives for the system performance. If sound quality is the top objective, we recommend using carbon film resistors. "Golden ears" say that they enable a full and rich sound, and they are frequently selected for superior sound quality in blind listening tests. To maximize performance specifications (SNR and THD), you should use metal film resistors. Be aware that these resistors tend to produce bright sounds that are often deemed "harsh" in listening tests.