a

PCB Layout Recommendations for the AD1981A CODEC.

1. Introduction:

This application note describes how to properly layout the AD1981A AC97 CODEC in order to preserve its specified audio quality. This is particularly important in a noisy digital environment such as a Personal Computer (PC) motherboard. The AD1981A CODEC can achieve over 90 dB of Dynamic Range and –90 dB of Signal to Noise Ratio, however this level of audio performance can be significantly compromised if adequate care is not used in the design and layout of the audio subsystem block.

2. CODEC layout overview:

Because the typical PC motherboard can contain excessive amounts of high frequency digital ground noise and power supply noise, ADI recommends that the AC97 CODEC and its supporting analog circuitry be placed in a quiet isolated area, away from the digital noise coupling sources. The CODEC should also be placed in very close proximity to the audio jacks in order to preserve the integrity of the analog I/O audio signals. This is one of the AC97 serial link advantages, allowing a flexible positioning of the audio section within the motherboard architecture. Figure 1 shows an optimal layout, with the audio section located in one corner of the motherboard and in close proximity to the audio I/O jacks.

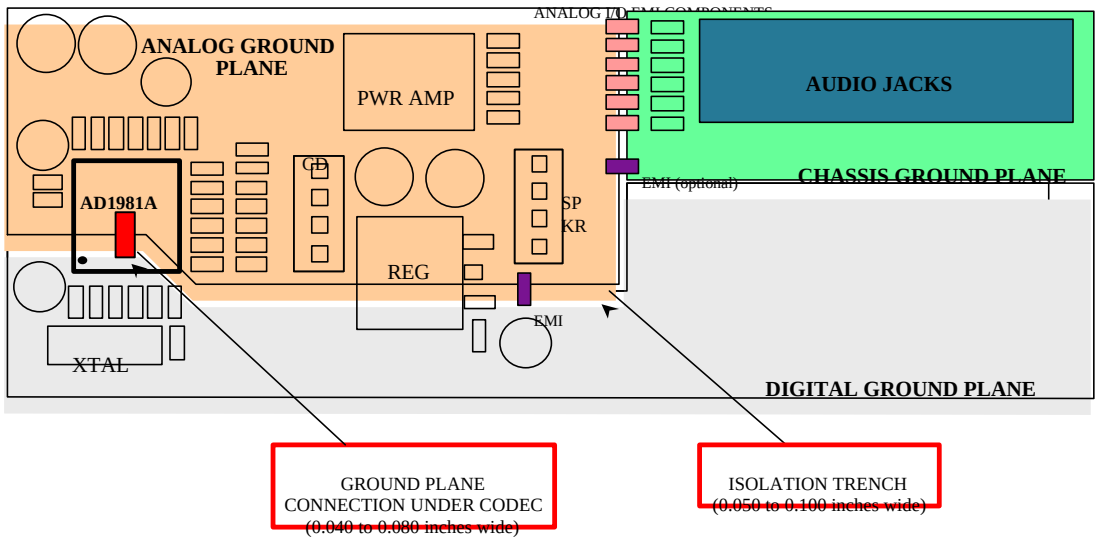

Figure 1, Recommended CODEC Layout

The CODEC isolated area should consist of a segregated analog ground plane area, which is isolated from the digital ground plane area by a moat (gap in the ground plane layer). This moat should be 50 to 100 mills wide and must completely isolate the analog ground plane area from the digital ground plane area, except for a single connection point at the CODEC. The connection point serves to reference the analog ground plane to the digital ground plane and typically consists of a small trace bridge under the CODEC.

The coupling of the audio I/O signals into the audio I/O jacks is normally implemented using EMI filter components for electromagnetic compliance and the audio I/O jacks are normally referenced and placed on a “quiet” chassis ground plane area (see figure 1).

For a multilayer motherboard, ADI recommends extending the separate ground plane philosophy to include separate digital and analog power planes, directly over their respective ground planes, with no overlapping of the planes. This gives an extremely effective, low ESR & ESL bypass capacitor consisting of the separate ground and power planes themselves, with an effective capacitance of ~5pF/cm2 (~30pF/in 2).

The IC leads should have pads and vias that go directly to the appropriate plane for power and ground. All digital components are mounted over the digital power/ground plane sandwich and all analog components over the analog power/ ground sandwich. This doesn't avoid the need for additional ceramic bypass capacitors at the IC pins as mentioned above. The importance and effectiveness of ground planes cannot be over emphasized to optimize the performance of the CODEC.

3. Ground planes.

The layout should provide for separate analog and digital ground planes on the same physical layer. All digital pins of the CODEC and all digital support components should be over the digital ground. All analog pins and analog support components should be over the analog ground plane (see figure 2). The analog ground plane should extend to but not enclose the audio I/O jacks area.

Digital routing should never run over the analog plane. If it is necessary to route a digital signal over the analog plane, the trace length should be short and the digital signal should be static. All analog routings should be over the analog plane. When analog signals need to cross the gap in the ground plane (when connecting the jacks for example) components such as ferrite beads or zero ohms resistors should be used. Signal traces should never cross the gap between the ground planes.

As mentioned above, from an audio standpoint the analog and digital ground planes should be electrically connected at a single point under the CODEC. However, it is a good idea from an EMC standpoint to place a few optional EMI components in a few strategic locations along the ground plane gap, so that the EMC performance can be optimized. Some recommended locations are: by the power supply regulator, by the CODEC corners and by the I/O jacks.

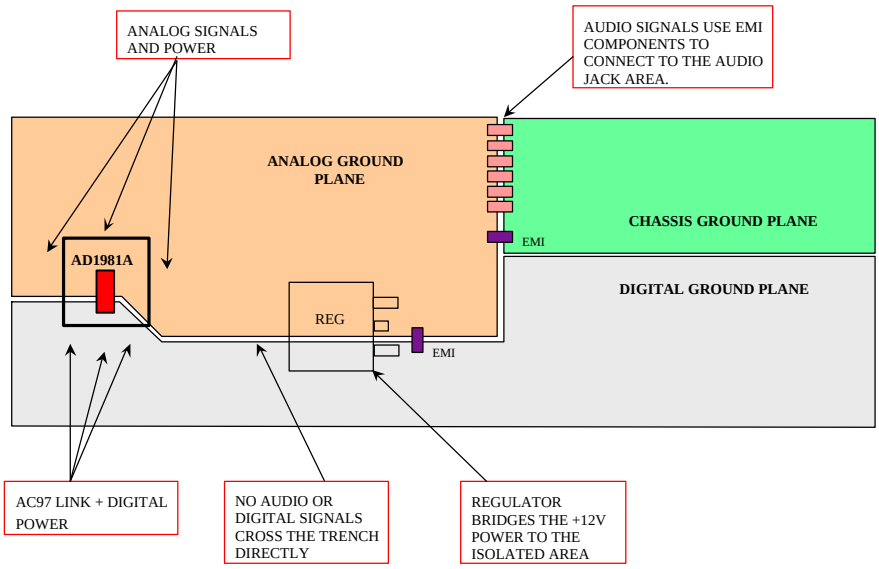

Figure 2, Ground Plane Connections

4. Power planes:

The power planes should be placed directly over their respective ground planes. That is, the edges of the AVDD power plane should align with the edges of the AVSS (analog ground) plane. The same is true for the digital planes, although in this case the digital supply is global so it may be difficult to get exact alignment. At a minimum the overlap of analog and digital plane should be avoided and the analog area should not be surrounded by digital and the digital area must not be surrounded by analog. All analog power supply connections and routing should be over the analog planes and all of the digital power connections and routing should be over digital planes. The input voltage to the regulator (8V, 12V...) should be a wide trace that routes over the digital ground plane. The voltage regulator itself should be located across the isolation moat, to transfer the regulated AVDD power directly into the audio subsection area.

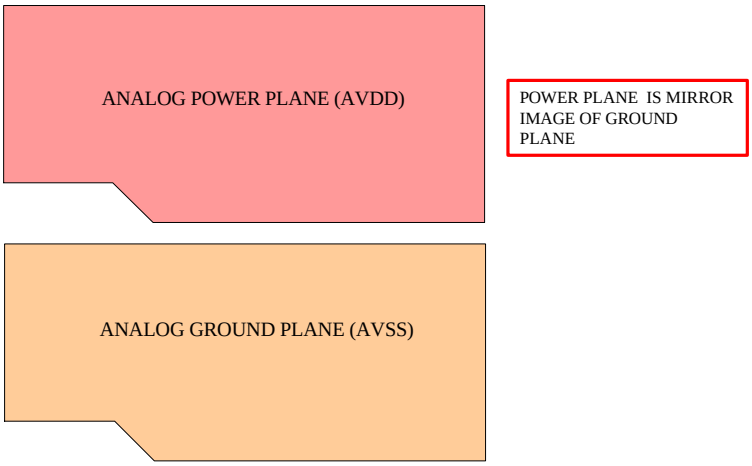

Figure 3, Analog Power Plane Configuration

5. Audio I/O Signal Routing:

On multi-layer boards, bottom layer routing of analog I/O signals is strongly recommended. This works exceptionally well with four layer boards where a “signal, power, ground, signal” layer stack, results in excellent shielding through capacitive coupling to the ground layer (see figure 4).

The microphone signal input trace in particular, because of its low level nature and higher CODEC input gain (+20dB boost) should be routed on the bottom layer.
Analog I/0 routing should be kept a short as possible. Keeping traces short decreases inductance and helps avoid magnetic coupling.

Regions between analog signal traces should be filled with copper. The copper fill should be shorted to the analog ground plane using several distributed grounding vias. This will help to guard and reduce high frequency interference by creating a capacitance coupling mechanism from signal to ground.

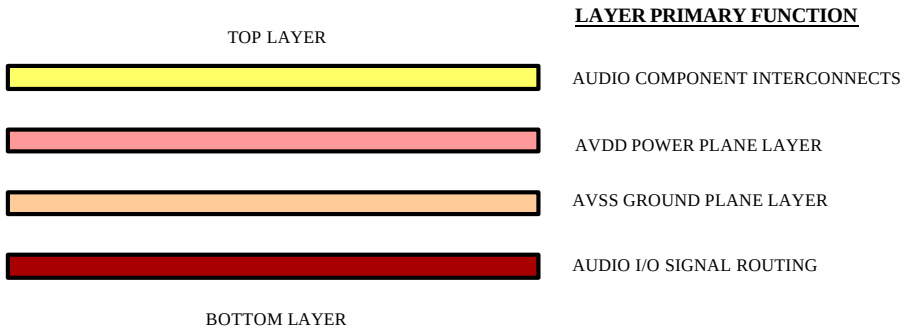

Figure 4, Typical PCB Analog Area Layer Stacking

6. Routing the AC-link:

The AC-link signals should be as short as possible. If the signal traces need to be long certain pre-cautions should be made to reduce ringing and signal reflections. Clock signal such as BIT_CLK should have a series resistor close to the CODEC. External clock sources such as the 14.318MHz or 48.000MHz clocks should have series resistor at the clock source. If a 24.576MHz crystal is used, series resistance is not required. This series resistance in the clock lines will help to reduce reflections. A shunt cap can also be used on these clock lines to help reduce ringing. Preferably the caps should be placed close to the clock source but should be electrically connected to the opposite side of the series resistor.

It is also recommended to place series resistors on the SDATA_IN and SDATA_OUT lines. The resistors should be placed close to the signal source. It is also helpful to place a series resistor on RESET#. This allows the CODEC to be isolated for debug and performance testing purposes. The use of ground trace shields may also help to reduce noise coupling and radiation from the digital link. Therefore, regions between digital signal traces should be filled with copper; the copper fill should be shorted to the digital ground plane using several distributed grounding vias.

7. Routing the AVDD, DVDD, AFILT and VREF caps:

All high frequency decoupling capacitors for the power supply pins, reference pins and filter pins must be placed and routed on the same top layer as the CODEC, using wide straight traces. This is done to eliminate using vias and therefore reduce inductance in the supply, reference and filter networks. Inductive loops in these networks can be a coupling mechanism for high frequency noise. High frequency noise can then be aliased down into the audio band during the A/D D/A process.

7.1 VDD/VSS Decoupling and Voltage Reference Bypass:

All high frequency AVDD decoupling caps (0.1uF ceramic) should be placed very close to the CODEC's AVSS pins. Each AVDD pin should have a ceramic cap in close proximity.
The high frequency decoupling cap for the voltage reference should also be placed close to the CODEC Vref pin and routed on the top board layer with wide traces to reduce impedance.
All high frequency DVDD decoupling caps should be placed very close to the CODEC's DVDD pins and have short wide traces connecting them to DVSS to decrease ground bounce and other noise coupling caused from digital switching.
The large 10uF low frequency VDD and 1uF VREF decoupling caps do not need to be placed close to the CODEC, but do need to be placed over the proper ground plane. That is, the DVDD decoupling caps should be placed over digital ground and the AVDD and VREF decoupling caps should be placed over analog ground.

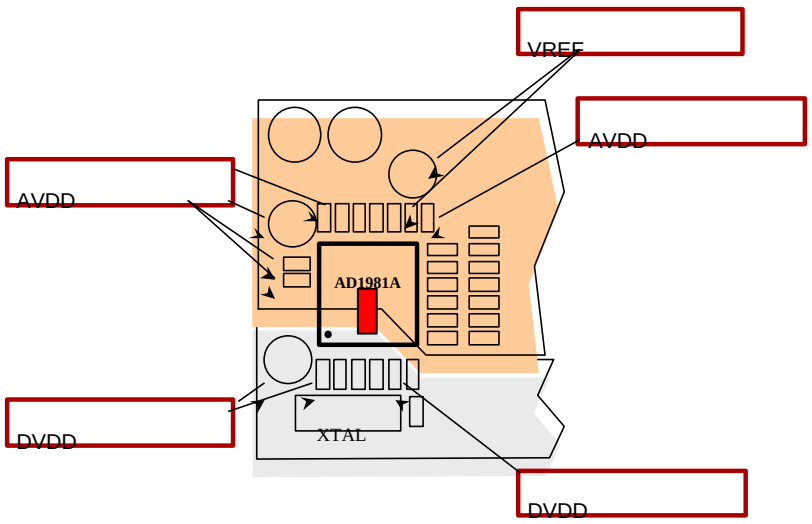

Figure 5, Power supply and Vref decoupling.

7.2 AFILT capacitors:

The AFILT capacitors serve as ANTI-ALISASING filters for the A/D, these caps must be top routed and placed very close to the respective CODEC pins. We recommend NPO type capacitors.

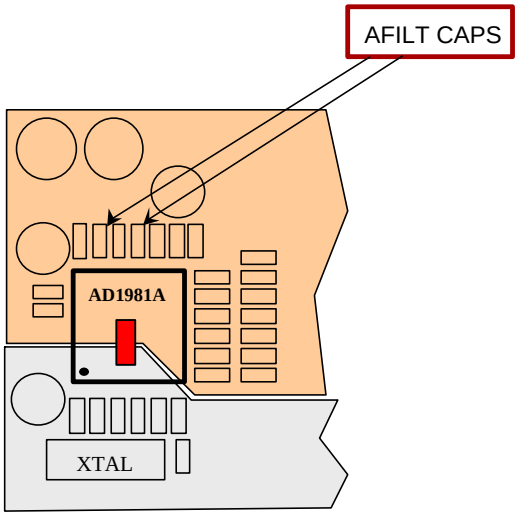

Figure 6, AFILT capacitors.

7.3 AC-Coupling Caps:

All the audio AC-coupling caps are not critical in terms of proximity; therefore, they can be placed further away from the CODEC.
Note that the audio AC-coupling capacitor's placement is neither dependent on the CODEC pin location or on the placement of the audio I/O jacks. The placement was chosen to keep the audio subsystem layout tight.
All audio input signal divider networks and filters such as the MIC voice filter should be located nearby to the respective CODEC inputs.

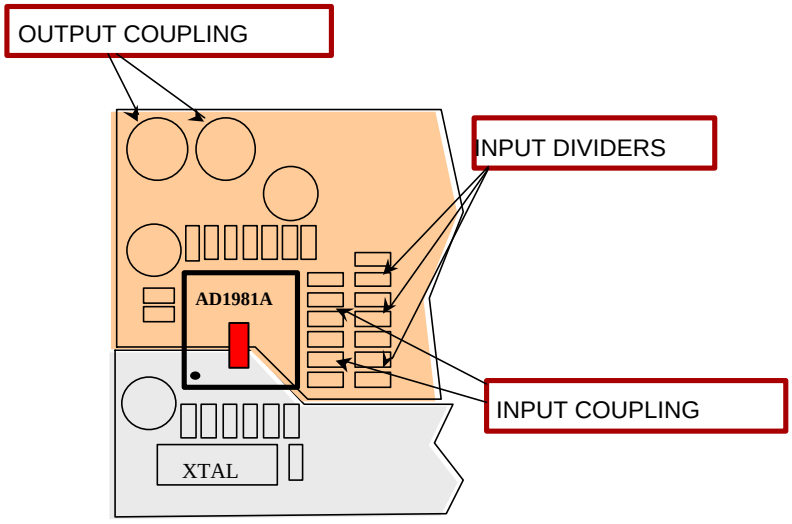

Figure 7, Input and Output AC Coupling Caps

8. Voltage Regulators:

The voltage regulator should be placed across the isolation moat so that the analog +5V routing is all done over the analog ground plane. The 12V supply routing including the decoupling capacitors should be made over the digital ground plane (See figure 2).

9. Internal Audio Connectors (Such as CD-ROM Molex connectors):

The CD headers and other audio connectors for things like internal speaker and telephony audio, can be placed anywhere over the analog ground plane. That is, they do not need to be close to the CODEC, but do need to be enclosed by a ground plane. The analog ground plane is chosen since it is the quietest ground and because it avoids crossings over the isolation moat.