Tempo Semiconductor, Inc.

General Audio Terms and Considerations

What are Hertz?

Hertz is a measure of frequency expressed in cycles per second. A pure sine wave has a tone at only one frequency. A complex waveform will contain combinations of many different frequencies at any one time. The typical range of human hearing is 20 Hertz (Bass) to 20 kilohertz (Treble).

What are some common sources of Noise?

Noise from mouse movement
Noise from stepper motors on disk drives
Pops and clicks due to uni-polar power supply
Inadequate power supply traces
Poor grounding.
Inadequate power supply
Microphonics
Ground loops

What are Volt expectations?

The expected line input and output level of a PC is 1 Volt RMS for PCs using 5 Volts DC for the analog audio power supply (AVdd). PCs using 3.3V power supplies for AVdd are expected to put out at least 0.707 Volts RMS. RMS stands for "Root Mean Square", and is a method for measuring voltages that corresponds more closely to the perception of the human ear.

1 Volt RMS
- Is the same as 1.414 Volts Peak
- Which is the same as 2.828 Volts Peak-to-Peak

What are the attributes of good audio?

- High Signal to Noise Ratio, or SNR
  - Freedom from noise
- Low Distortion, or THD+N
- Freedom from distortion
- Full-range frequency response
  - Match the range of human hearing
- Low channel-to-channel crosstalk
  - Minimize leakage between audio channels

What are the different types of Noises?

There are many different types of noises. Hissing noise or white noise is typically steady state, and usually derives from the thermal noise of the components in the subsystem. Occasional or intermittent noise usually comes from other components, such as mouse movement, hard disk noise, CD stepper motors, RF circuits, memory strobing, video activity, and switching power supplies. Be sure to check noise while other components are in use. Reduce this noise by using components designed for low noise operation. The choice of audio codec is critical for low noise.

What can affect Audio?

Everything affects audio!

- Audio sub-section Layout
- Audio Power supply
- CD/DVD analog outputs and power supply
- CPU Power supply
- External power supply (laptop)
- Battery charge circuit (laptop)
- Case grounding
- Jack grounding
- EMI suppression techniques

What do I need to consider for CD Ground?

The CD_GND pin is often mistaken as a true GND connection and is connected directly to GND. This pin is actually a common mode CD input and must be connected to analog GND through a capacitor. If the CD_GND pin is not connected properly, especially if it is connected directly to analog GND, it will result in audio noise and performance problems. It is very important in each audio design to treat the CD_GND input as an analog input, not a GND pin.

What do I need to consider for Laptops or All-in-one Models?

Models with built-in speaker systems have additional considerations. Typically the larger the screen, the louder the expected listening volume. Loud listening volumes require a well-filtered power supply capable of providing peak currents in excess of the maximum current consumption of the power amplifiers. If the power supply is not well-filtered and regulated, or if the power supply traces are not wide enough, then the output amplifier can become unstable at high volumes.

What do I need to consider for Microphones?

Microphones typically require extra preamp or gain stages, which may add between 20 dB and 62.5 dB of additional gain. For external microphones, make sure that the microphone bias supply is super-clean (i.e., noise-free). Keep microphone connections to a minimum length, preferably within an inch or two of the codec. For longer microphone runs, use a microphone with a built-in preamp of 20 dB or more. Generally avoid preamps which are not inside the microphone or near the microphone. When wiring for stereo microphones, maintain maximum isolation between bias supplies, to ensure low crosstalk; this is especially important for beam-forming or phased-array microphones, as excessive crosstalk will cancel out the beamforming effect.

What do I need to consider for Power Supply?

Use a codec with a good PSRR (Power Supply Rejection Ratio) to minimize noise being induced from the power supply. This is especially important for designs which don't have a dedicated voltage regulator. Be especially careful with power supplies which provide mic bias voltage. Any noises on this supply will be amplified by the microphone preamp. For instance, a small 10 microvolt noise on the supply, amplified by a typical 40 dB preamp, will result in a noise floor of -60 dB, which cannot pass WHQL requirements. Whenever possible, leave a stuffing option for a voltage regulator even if a voltage regulator is not planned as part of the final design. This can prevent an expensive board re-spin late in the design cycle. Try to always bring up digital power supply before analog power supply, and return analog power supply to zero before removing digital power supply. Fast turn-on or turn-off of analog power supply will cause pop noises.

What do I need to consider when it comes to Testing?

Be sure to test under dynamic conditions.

- Listen to and measure SNR on both record and playback paths
    - While moving the mouse
    - While running Disk Defragmenter on each hard disk
    - While copying large files to and from CD/R
    - While copying large files over Wi-Fi and/or LAN
    - While exercising memory
    - While exercising video

What is Frequency Response?

The frequency response is the bandwidth of the audio passband, and should match the range of human hearing, that is 20 Hertz to 20 Kilohertz; The edges of the frequency response are the frequencies at the upper and lower end where the level drops below -3 dB compared to normal; A flat response curve is desired (less than +/- 0.5 dB or less).

What is High Signal to Noise Ration or SNR?

A Signal to Noise ratio of 100 dB means that the loudest signal is at 0 dBV (or 1 volt RMS) and that all measured noise signals are no greater than 10 microvolts. An SNR of 100 dB is a good goal for media-centric designs. This requires a high-quality codec with greater than 16-bit resolution along with a good layout. For 100 dB SNR performance, all stray noises together must equal less than 10 microvolts RMS, or 28 microvolts peak to peak.

What is Star Grounding?

Star ground is accomplished by running a separate trace for each analog ground (return) shown on the schematic back to a central grounding point underneath the codec. Ground planes should only be used for shielding, and should be attached at a single point. Ground planes should never carry any current. Connect digital ground and analog ground together directly underneath the codec. Ensure that there are no other “ground loops” or additional return paths, as these can cause noises to be induced into the audio. Take special care with shielding around the jacks, as well as EMI and ESD circuitry. Shields must be grounded in only one place, and connected directly to the main ground underneath the codec. Ground return traces must be capable of handling as much current as each associated supply trace. An overly small ground return trace can cause noise due to the voltage drop over the resistance of the trace. Star grounding is counter-intuitive for board designers who are unfamiliar with audio layout best practices. Use Optical SPDIF output or use transformer for coaxial SPDIF Out.

What is Total Harmonic Distortion or THD?

A pure sine wave has a tone or energy content at only one frequency. A complex waveform will contain combinations of many different frequencies at any one time. Distortion is a change or deviation between input and output signal. Harmonic Distortion is deviation from a pure sine wave, which includes the energy at frequencies which are multiples (harmonics) of the original signal. For instance, a sine wave at 100 Hz has harmonics at 200 Hz, 300 Hz, 400 Hz, and so on. Harmonic distortion is generally undesirable, but is harder to hear than noise. THD+N measures both harmonic distortion and noise. If a system is very noisy, then the SNR and the THD+N will probably be the same. For a well designed system, SNR will usually be better than THD+N. A THD+N of -90 dB is a good goal for media-centric designs. THD is mainly influenced by the codec and amplifier designs. Noise is mainly influenced by both the components and the circuit layout.

What is a decibel or dB?

A Bel was named after Alexander Graham Bell, the inventor of the telephone. It is a unit which defines a doubling of loudness. A decibel is 1/10th of a Bel. A decibel is commonly expressed as a ratio of two values

0 dBV is referenced to 1 Volt RMS; Each doubling or halving of voltage is approximately 6 dB

dB FS (Full Scale) is a measurement of digital signals relative to the maximum possible value

0 dB FS = maximum value possible, all other levels are expressed as minus

The average human ear has a dynamic range of over 10 Bels, or 100 dB. Voltage is linear scale, dB is log scale. A range of 60 dB is a ratio of a thousand to one. A range of 120 dB is a ratio of a million to one. 3 dB is the smallest volume step that a typical untrained listener can easily discern; trained listeners can identify smaller steps.

What is an Octave?

An octave is a doubling of frequency. The average human ear has a frequency response of over 10 octaves. Hertz is linear scale, octave is log scale.

- 10-octave ISO (International Standards Organization) center frequencies
  - 31.25 Hz
  - 62.5 Hz
  - 125 Hz
  - 250 Hz
  - 500 Hz
  - 1000 Hz
  - 2000 Hz
  - 4000 Hz
  - 8000 Hz
  - 16000 Hz

Note that the ear has log response for both frequency (octaves) and volume (db), but our test equipment normally uses the linear scales such as Volts and Hertz.

Why Isolate?

HD Audio and AC97 buses allow a 5-wire serial connection between the codec and the controller. Take advantage of this to locate the codec as close as possible to the jack, and as far away as possible from other circuits in the computer. Use an isolated voltage regulator designated exclusively for analog audio power supply, as close to 5V as possible. Try to eliminate any coupling (magnetic, capacitive, or electronic) between the audio circuitry and any other circuits in the computer. If possible, build a “guard ring” around the audio circuitry, and don’t allow any other circuits within this area. Avoid routing audio traces near other circuitry, especially high-speed digital circuits. For external analog connections use twisted-pair shielded wires with the shield connected only at the input end; avoid using ribbon cable or unshielded cables for analog connections. Locate audio circuitry away from wireless LANs such as 802.11 and Bluetooth.