GETTING A PERSPECTIVE ON NOISE IN AUDIO

The obstacles in building and maintaining audio systems which are noise-free and reliable can be summarized as follows:

1. equipment manufacturers are not sensitive to the difficulties of systems interconnection and continue to build electromagnetic interference (EMI) sensitive equipment — users continue to purchase this equipment;

2. many audio systems are built with little or no actual design in the grounding and interconnection department, being simply lashed together; or where there is design, it is ill-conceived;

3. as a result of the first two items, the systems operator may, in an effort to reduce a specific hum problem for example, make changes to the systems wiring (generally ground or shield lifting) with little understanding (or even concern) for overall system effects. This resulting lack of consistency within the system can make debugging chronic and other system configurations EMI-prone.

There are many reasons for lack of planning and foresight on the part of equipment manufacturers, system builders and designers. In short, it is a statement about the audio industry's inability to standardize on some basic issues. Some time in the future, all interconnection will be fibre optic and EMI will be a thing of the past. Until that time, however, system designers and users will be cursed with the inadequacies of the present interconnection systems, be they analogue or digital. Therefore, time and energy must be spent to get the best performance from our systems.

What is Noise in Audio Systems?

Noise is any unwanted signal that gets into the audio signal path and is transmitted through the system. In the case of systems that use electrical signals — as opposed to technologies such as fibre optics — this noise is EMI. As the name implies, the noise is due to electric or magnetic energy. EMI manifests itself in audio as hums, buzzes, whistles, signal distortion and crosstalk, to name a few.

Where it Comes From

EMI can come from anything that uses electricity to operate, as this results in voltages and current and associated electric and magnetic fields. While all electrical equipment generates EMI, in most cases it is too weak or of a nature as not to be detrimental to audio equipment. Typical electrical equipment that can be problematic include: high-power RF transmitters; low-power nearby RF transmitters; large motors and other heavy industrial equipment with switched inductive loads; lighting dimmers or other equipment which chops or switches the AC sine wave.

High-voltage devices or RF transmitters which are some distance away create electric fields, while high current devices create magnetic fields. Magnetic fields only pose a concern when nearby.

How EMI Travels

EMI travels either through the air or conductive wires as electric or magnetic fields. In many cases, a combination of these elements exists. For example, dimmer lighting circuits that run in a building containing chopped sine waves may radiate energy which is picked up through the air by a guitar pick-up or cable.

Electric fields create voltages in the circuits they strike. In fact, the coupling between an electric field source and a victim circuit can be modelled as a capacitor between two wires: the coupling improves as the wires get closer together, have a greater common area, and/or as the exciting frequency goes up.

Magnetic fields create current in the circuits they strike. For the current to flow, there must be a loop for this circulating current. The magnetic field may strike the loop in only one place, such as a ground conductor or one conductor of a balanced line. (In the latter case, the loop consists of the source output, one of the balanced conductors, the driven input, and the other balanced conductor.) The coupling between a magnetic field source and a victim circuit can be modelled as the mutual inductance between loops of wire: the coupling improves as the wires get closer together, have more turns of wire or a greater loop area, or as the exciting frequency goes up.

As both electric and magnetic coupling increases with frequency, the chopped sine wave AC power (which contains frequencies much higher than 60 Hz) will be a greater EMI threat.

How EMI Enters Audio Equipment and What Its Effects Are

It is very rare (although possible) for EMI to enter a piece of equipment through the air and be picked up by the circuits within the equipment. (It could occur with a walkie-talkie used beside a console, for example.) EMI more commonly enters equipment via the AC power cord or the interconnecting signal or control wire connected to it. In other words, EMI on the power or ground lines may travel down the line and into the equipment power supply; or airborne EMI picked up in signal or control wiring may enter the equipment through the inputs and outputs.

The input and output impedance of the interconnecting circuitry will influence its EMI immunity. Circuits which are below 600 ohms tend to be affected by magnetic fields, while those above 10,000 ohms tend to be affected by electric fields. Circuits in between may be affected by either.

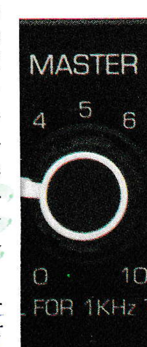
The electric signals transmitted between two pieces of equipment are referenced to the ground of the output circuitry. EMI, which is present everywhere in a facility, may create current and voltages on the ground reference system. If the input circuitry is not referenced to the same ground potential, a noise voltage at the input is created. If the system is balanced, it will reject this common mode ground reference noise up to a frequency where the input is well balanced (Note that common mode rejection ratios fall off with rising frequency.)

If an interconnect is not well-balanced, it is also possible to have common-mode to differential-mode conversion. This occurs when the impedance-to-ground of both sides of the balanced line is not exactly equal, and the signal on one side is partially shorted-to-ground or impeded: hence, a differential exists. A common-mode signal is thus converted to some extent to a differential-mode and passes through the balanced input. Unbalanced interconnects that have no ability to reject common mode noise are vastly inferior in their EMI immunity.

Once in the equipment, EMI creates voltages or current that mixes with the audio or control signals and becomes noise. It is also possible for EMI signals which are well above the audio band (20 KHz) to be inadvertently demodulated down in frequency (in a manner similar to a radio receiver) and become a problem. Also, out-of-band EMI signals can be so strong as to overdrive inputs and result in distortion of the in-band audio signal.

Basic Means of Controlling EMI

There are only three ways of controlling EMI: reduce or eliminate it at the source; remove or reduce the effectiveness of the path through which it travels; or make the victim more immune to its effects. There are



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