SHUNYATA RESEARCH

Electrical System Concepts

Before examining methods of setting up an ideal electrical delivery system for recording, music and sound reproduction, it helps to understand why electrical conditions have a profound impact on sound.

The Importance Of Electrical Delivery To Recording And Sound Systems

Too often, the AC system is misunderstood in its relationship to the performance of recording or playback systems. This can lead to the misapplication or over-application of AC treatments — or the extreme of ignoring the power-delivery system as inconsequential altogether. In both cases a corruption of the system's most fundamental signal will be the result.

The Source of Sound

When referring to a playback or recording system's “source” most people will make a reference to the actual media, whether it is voice, instrument, a record, CD or tape. However, from the perspective of electronics systems there is a far more fundamental, underlying “source” than the media being transported through a recording or replay system.

The actual source of what we hear in any recording or playback system is the power as supplied from the wall after being rectified by the power supply into a relatively stable DC source. It is this DC power source that is the fundamental energy source that makes sound possible. For example, in an amplifier it is the DC source current (modulated by the signal source) that drives the coils in a speaker. If the power source is unstable or contaminated then the output will be as well regardless of the information in the signal source. If the AC power varies or if there's some anomaly in the power source it will show up clearly in the audible range. The assumption that power supplies provide perfect noise-free DC voltage that does not vary under load, is fanciful at best, complete fiction at worst. There is no such thing as a perfect power supply capable of filtering, blocking or managing multiple forms of high-frequency EMI and RFI interference produced by electronics systems. In the simplest terms, alternating current represents the foundation of reproduced sound in recording, sound and music systems.

A Historical Brief

For years, the predominant approach to an AC system was to install a large, usually heavy, multi-outlet box with some type of massive low-pass filter ie: transformer, choke or coil. These were designed with the view that AC delivery is a simple, low-frequency event requiring protection only from external, grid-related sources of high-frequency noise, line spikes and voltage surges. These boxes were viewed as virtual brick walls, keeping out all grid-borne noise, surges or spikes that posed challenges to the performance and safety of electronic systems. However, two principle issue were overlooked. The primary issue with the low-pass filter or regenerator approach lies in their inability to deliver instantaneous peak current impulses to full-wave bridge-rectifier or digital switching power supplies in the time in which they would normally receive them from the wall. The second and equally important consideration is the fact that these one-way noise rejecting designs also block noise generated by the components themselves, reflecting that noise back to the other components in the system.

Upon Close Inspection

Electronic power supplies don't pull current in a linear fashion like a light bulb, fan or simple motor would. The full-wave bridge rectifiers and digital switching supplies in electronics draw hard on the AC line, pulling instantaneous bursts of current off the highest and lowest peaks of the sine-wave. This happens within milliseconds in order to fill power supplies storage capacitors. Both full wave bridge rectifiers and digital switching supplies create a significant amount of noise during this process that extends in frequency to the 50th harmonic of the line frequency. What this means, is that from the perspective of power-supply, AC transmission is a near-field, high-frequency occurrence not a low frequency 50-60Hz event.

With this basic understanding of the role AC plays in sound and the high frequency noise electronics systems create, two key elements emerge that are paramount in building an ideal power-system: Dynamic Transient Current Delivery™ (DTCD®) and Component to Component Interference™ (CCI™).

DTCD® — Dynamic Transient Current Delivery™

Maximizing the unimpeded instantaneous and continuous flow of current to electronics is critical to recording and playback systems performance. Recording and sound playback electronics are designed to perform optimally through an unrestricted interface with current. This is as true for source electronics as it is for amplification. Placing anything in front of an electronics system that restricts, impedes or slows the DTCD® of AC power will degrade the ultimate performance of the system. This is why most electronics manufacturers discourage the use of power conditioners that interfere with instantaneous current flow. Starting at the AC panel there are simple methods and measures anyone can implement to improve their entertainment system's instantaneous access to its power source without compromising protection or performance.

CCI™ — Component to Component Interference™

A primary concern when building an electrical delivery system for recording or sound should be the isolation of individual components from the high-intensity fields of EMI and RFI noise that saturate the space surrounding electronics systems.

The power supplies of sound and recording electronics are by nature interconnected and in close proximity to one-another. All components in these systems have a unique electrical footprint and output noise from their digital switching or bridge rectifiers within the power supplies. Power supplies generate significant EMI primarily from the switching rectifiers. Digital equipment also generates high frequency RFI.

Both RFI and EMI may be transmitted from one component to another in several ways. The first is through conduction via the power cord connections and through interconnects. The second is through inductive coupling via power cords and other electronics connections.

Not only do power supplies emit a back-wave of noise energy through the ground system and power cords, their digital switching supplies or rectifiers radiate intense fields of gigahertz EMI. This affects all electronics and cabling within their immediate environment.

By far the most effective means of minimizing the impact of this noise lies in treatment of the initial outward points of electrical interface for each component — the power cord and the system's main distribution points, the AC distribution buss/power conditioners.

A properly designed power cord can act as the first line of defense by isolating the power-supply port and IEC area from the radiated energy that surrounds electronics. They should also act as low-impedance path for the back-wave of power supply noise to reach an exit path from the system. Power cables that have low measurable impedance, resistance and reactance are preferable because they can provide a neutral connection for reactive power supply signatures and allow the cleanest exit path for ground noise to be dissipated/filtered at the connection with the distributor.

The primary role of the power distributor — outside of providing optimal DTCD® and simple protections from spikes and over-voltage — should be to provide a passive exit path for system-generated noise. The best distributors will offer individual component isolation so that the ground noise flowing out from one component does not affect other components plugged into the same AC distributor. It may sound simple and that is the goal. Power distribution should be an uncomplicated delivery path for the instantaneous AC impulses that allow electronics to perform at peak efficiency.

Contrary to popular theory, grid related or external noise generated outside of a systems immediate environment is vastly over-rated as a threat to system performance. Most if not all quality electronics have built in power supply elements that are more than capable of filtering or re-directing incoming noise — which pales in its effect to the massive amount of noise that is generated within the system. Given that the most sensitive electrical elements lie within recording and playback systems, this is a good place to start in building an ideal power-supply chain; one designed to deliver maximum current and minimum AC related distortions.

The fundamental design of interconnects, power cords and power distribution can radically affect EMI and RFI contamination — which in turn will dramatically affect the resolution and detail in recorded or reproduced sound.

Keeping It Simple

If we accept that electronic power supply's interface with current is a high-frequency, dynamic (short-term) event then it becomes clear that the ideal signal path for current should be direct, with minimum added complexity. Providing simple, unobstructed, low-impedance pathways for current using solid connections and high quality materials will yield by far the most consistent and desirable results. The closer the signal navigates toward electronics the more critical these elements become. Conversely the more complex, obstructed the path, or the more reactive elements that are used between the panel and a system of electronics, the more compromised and unpredictable the results will be. Keep in mind that reducing perceived noise is only valuable if it can be done without restricting or impeding DTCD®. Some may value a reduction of perceived noise to a degree that makes losses in timing, immediacy and dynamics tolerable but when compared to sound that is uncompromised with regards to dynamic contentandhas noise isolation, the choice is clear.

The power-system components that are easiest to control, such as power breakers, grounding, dedicated lines, outlets, power distributors and power cords should perform two simple functions. Each part of the AC chain should be treated or selected to provide Dynamic Transient Current Delivery (DTCD®) to the electronics or when close to the system itself, to isolate the effects of radiated or conducted.