

## Interview

# Shunyata Research Founder Caelin Gabriel talks with Robert Harley



**Robert Harley: Tell us about your background and how you got started building AC power systems for audio.**

**Caelin Gabriel:** In school my area of study was the physical sciences. Once out of college I was recruited by a military division of the N.S.A. I was trained in the areas of digital data acquisition and encoding, which included the study of electronic power supplies. My work in the military had to do with the development of equipment that could detect and lock onto low-level transmitted signals that were theoretically impossible to resolve at that time. Shortly after leaving the military, my work

involved studying the effect sound had on human biology. Later, I worked in the computer industry, primarily with high-speed networking gear like Ethernet devices, routers, bridges, and fiber-channel components.

**RH: Did working on low-level signals influence your design of AC power-conditioning systems**

**CG:** Yes, it became the foundation for my ongoing research into the complex nature of electronic power supplies and how they affect low-level-signal acquisition and resolution. My work in this area had crossover applicability in the role system-generated noise plays in audio recording and playback. Contrary to popular theory and design practice, we learned that the radiated EMI and power-related noise generated within systems of interconnected electronics was a more likely threat to the resolution of detail than noise sources from outside of the system. Addressing the near-field distortions and high-frequency noise generated by the bridge rectifiers, digital architecture, and switching supplies in the system itself brought about the greatest improvement in the resolution and fidelity of reproducing detail.

**RH: What are some misconceptions you think that audiophiles have about AC power and power conditioners?**

**CG:** There are quite a number, so I'll address only the most common related to our research and approach to designing power systems.

The primary misconception considers that AC delivery to electronics is a simple, low-frequency process since AC power is only a 50Hz or 60Hz event. This simplistic concept leads directly to products that employ a variety of multi-outlet low-pass filters involving the use of transformers, chokes, or inductive coils. These designs are all based on the premise that protecting electronics from power-grid related spikes, surges, and noise will deliver superior sound and performance from today's best AV systems. On the surface, this seems to make sense and most

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of these devices work as advertised by redirecting, filtering, or regenerating the incoming AC waveform.

The problem with these concepts is that they do not account for the dynamic way in which power supplies function or the effects of noise generated by and shared within the electronics systems themselves.

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 peak of the sine wave. This happens within milliseconds in order to fill power supplies' storage capacitors. What this means is that from the perspective of power-supply function, AC transmission is a high-frequency, not a low-frequency event. If electronics are plugged into a low-pass filter or inductive device, this leads to two fundamental problems. One, inductive devices that are in line will slow the charge rate to the power-supply capacitors. From our experience the impedance of instantaneous current flow to power supplies in audio equipment leads to a notable loss of phase and timing accuracy in sound. This is most often heard as a loss of dynamics or immediacy. The second, equally problematic issue is caused by the low-pass-filters that were intended to improve sonic performance. They block external noise by nature of their inductive reactance; however and conversely, they will also prevent system-generated noise from finding an exit path. This aspect will tend to trap power-supply-generated noise and reflect it back to the component and also contaminate the power line to the other equipment that is connected to the same power conditioner.

The primary design goal for our power distributors is to maximize instantaneous current delivery while minimizing inter-component noise contamination. We use simple-order filters to eliminate adverse power-conditioner reactance, ensuring that our conditioners will perform consistently with the broadest possible range of electronics systems. When the designers of top-performing recording and playback electronics create their power supplies, if they wanted another inductor in line with the primary coil of their transformer, they would have put it there. If they wanted some other type of reactive device that resonates at certain frequencies, it would already be within the design. Manufacturers of today's finest-caliber sound and recording components designed their power supplies to interface with the original AC waveform, not one that has been processed, redirected, or impeded.

As much as possible, our goal is to follow the Hippocratic principle of doing no harm. Then, if we can do something positive without creating corresponding negatives, that's what we would want to design into our products. These principles are what lead us to develop the first passive power conditioner of its kind in the original Hydra. This is also what has led to the support we receive from the electronics manufacturing community and studio industry.

**RH: Why does the last six feet of power cord make any difference when miles of bad wire precede it?**

**CG:** This goes back to the first misconception, which is that power transmission is a simple concept. In actuality when you're

connecting multiple devices to the power line, you're essentially connecting them all to the same electrical point, so you're tying them all together. If just one of the components in any connected system is back-loading noise into the power supply and ground, then all of the devices that are connected to that power line are going to be affected by it. In most cases there are several components in each system which generate and transmit enormous amounts of high-frequency noise that no power supply, no matter how well designed, is equipped to manage.

Our power cords are designed to act as sympathetic, noise-isolated extensions of the primary winding within a component's power supply. Seen this way, their function takes on a more prominent and understandable role. They represent the initial outward electrical interface for each piece of electronics in the system. That initial interface can act as an antenna for radiated and ground-borne noise or it can be engineered to isolate the power supply from internal and externally radiated EMI, RFI interference.

Power cords do not represent the last few feet of an AC grid leading to a component; they are the first few feet from the perspective of the component's power supply. The further a potential noise source is from a component, the less impact it will have upon the circuitry within the component.

**RH: What are the primary mechanisms by which AC power affects sound quality?**

**CG:** This is almost a misconception in itself and so I'm going to start from the beginning with a statement. It doesn't affect sound quality—it is it. First, you must understand a fundamental principle. In audio we think that the source is the signal that is embedded or encoded on some media, i.e. a record, CD, or tape. The actual source of what we hear is the power as supplied from the wall, rectified and filtered by the power supply into a relatively stable DC source. It is this DC power source that is the fundamental source of everything. It's what moves the coils in a speaker.

**RH: The audio signal doesn't get "amplified"; the output transistors modulate the flow of DC from the power supply in a replica of the input signal.**

**CG:** Absolutely right. So the source for the power is the AC that comes from the wall and is manipulated in such a way that it's ideally stable, unaffected, noiseless. But we know this is not the case when we actually build devices. If the power source is unstable or contaminated then the output will be also. If it varies or if there's some other anomaly in the power source you will always hear it. So power is the foundation of reproduced music in audio systems.

Having made that point clear there are two primary mechanisms related to AC power that affect sound quality and still others, which are less quantifiable. Current-delivery plays an obvious role, especially near the power-supply inlet. The conductors are important including the type of metal, gauge, wire geometry, and dielectric type. Quality contacts and reliable terminations are critical to an end result.

The other primary AC-related factors that can affect sound are electromagnetic field effects. These include radiated 50Hz-60Hz AC, radiated rectifier-induced pulses, radio frequency interference from electronic circuits kicked back to the power inlet and power cabling. And of course, all the external sources of RFI such as

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WiFi, light-dimmers, cell phones, and other electronics.

There's actually a third causative aspect to power system performance. The third one is what most people don't want to talk about. There are many aspects which can be measured and there are those which cannot. When doing research year after year, you will occasionally stumble across something that affects sound quality but is not possible to measure. You can hear the effect, you can repeat it, but you can't find a scientific foundation to attach it to. These things do exist, and if you want to have the best products you have to pay attention. If you just put blinders on and say I'm only going to address the things that I can measure, I don't think you can be at the top of your field—not in this industry. This is why we test everything—not just with spectrum analyzers and oscilloscopes but with listening tests also.

Based on 25 years of research it is clear to us that system-generated, -radiated, and -propagated noise has by far the most profound effect on the performance and resolution of the critical timing, phase, and detail elements in sound. Power cords and power distribution should act as near-field isolation devices to minimize the effects of all these forms of noise. They should accomplish this *without* interfering with the current flow to, or the performance of the attached electronic equipment.

## **RH: What is the most effective method of judging the performance of AC power products?**

**CG:** Really, no differently than you would judge electronics or speakers with a few key exceptions. Make sure you apply four to five days of current through to the power cord or power distributor, if it is new. If you are considering replacing stock cords, replace all of them at once and compare. Otherwise a single quality AC cord could merely highlight negatives or have its effects mitigated by all the stock cords in the system. Evaluate stock cord replacements as a system whenever possible. Keep in mind that a power-distribution chain functions ideally as an integrated system and not as a random accumulation of disparate parts.

We design our products to function ideally as a system, so comparing one of our power cords in a mixed system is of little value other than to judge the one cord's synergy with other random products. Do not mix or cascade power conditioners or you will end up with a very reactive and possibly unstable power

delivery system. Do not compare power conditioners while another unit is plugged into the same outlet—they interact with one another even if they are off.

## **RH: What's different about Version 2 of the V-Ray?**

**CG:** Other than more minor updates, the Hydra 8 and Hydra 8 V-Ray had gone unchanged since their inception almost eight years ago. We developed a new version of the noise-reduction compounds that absorb noise and dissipate it as heat within its molecular structure. However, the new compound, that we call ZrCa, proved to be dramatically more transparent and achieved higher levels of resolution compared to the old compound. The new Hydra 8 v2 and Hydra V-Ray both benefited in the areas of ultimate transparency, immediacy, and dynamics from this single change. We have also made refinements to the capacitive filter network, which brought about even greater levels of resolution and clarity.

## **RH: What's new in the CX Series of power cords?**

**CG:** Our ongoing research into conductor design and technology proved that with our patented Helix geometry, adding conductor mass to the design made dramatic improvements in performance without adding cost to the existing models. Designing the new products with hundreds of individual interlaced conductors as opposed to between 10-20 conductors for the previous generation made a significant difference in performance. We have been very pleased with the response to the new CX models from our dealers, studios, and electronics manufacturers.

## **RH: Did you approach the V2 products and the CX Series with a goal of achieving a specific sonic result?**

**CG:** No, we never do that. What we do is we are constantly testing and researching anything that catches our interest, and so if we develop a new conductor technology or a new geometry or a new trial process or something that we feel is significant to the sonic results, then we will take that and incorporate it into the next version of the product. We are in a constant state of research, but we don't design with anything specifically in mind. We're always trying to just improve the products in general while trying to drive down the retail cost for the products. This is what has kept us competitive. **tas**