DNA Products In Audiophile Applications

(MxDNA, RxDNA, PxDNA, DNA-Line-Filter)

1.0 Introduction

1.1 General

This paper describes the noise reduction mechanisms associated with the MxDNA2500 and MxDNA1250 products. A brief description of the MxDNA products is included.

Test were conducted of the completed MxDNA design in several locations. In the case of evaluating the MxDNA performance in the enhancement of high-end audio equipment, certain unexpected results were experienced. These results were the inspiration for this paper. This paper will document the examination of the interactions of signals (noise and music) and offer a postulation of the improvement mechanisms.

1.2 MxDNA2500 and MxDNA1250 Product Descriptions

The MxDNA products are designed for the 50/60 Hz. power lines. They accomplish the reduction of high frequency noise. The frequency range over which these products are effective is approximately 5 Khz to 500 Khz.

1.2.1 Noise Sources

Noise in this frequency range can come from a wide variety of sources. They include the following.

- Noise from switch mode power supplies that power various electronics that are connected to the A.C. line, including computers, office machines, uninterruptible power supplies (UPS), entertainment electronics, etc.
- Harmonics from traditional power supplies (not switch mode supplies) that power various electronics, noted above.
- Harmonics produced in the utility network itself from various sources, most notably, BH curve non-linearity's in transformers from being operated too close to their maximum ratings, i.e. driven close to or into saturation.
- Harmonics produced in the utility network from the turn on surges of the customer's equipment, can drive transformers into saturation. This is a sporadic generation of noise/harmonics, but is a sever-enough problem to be a special note.
- Harmonics from electrical motors.
- Broadband noise from electric arc welders. This is severe, intense noise.
- Broadband noise from induction heaters. This is severe, intense noise.
- Broadband noise from relay and mechanical switch actuations, both D.C. and A.C.
- Broadband noise and harmonics from motor speed controls, light dimmers and solid state switches. The latter includes SCR's and Triacs.
- Noise from Radio Frequency (RF) transmitters. This is usually an intermodulation product noise from two or more transmitters. This means that the transmitters might be a higher frequency than the frequency range mentioned above for the MxDNA, but they mix together in some non-linear device and produce the sum

and the difference frequencies and these latter frequencies are in the aforementioned MxDNA range.

- Last but certainly not least is the noise that is an alias of some other signals (noise) in a system. This type of noise is an artifact of the way that the noise combines with other noise and intended signals. It is most prevalent where there are non-linearity's. Inasmuch as there are non-linearity's in almost any AC or DC power system, this phenomenon exists many places.

1.2.2 Filter Products

"Power conditioning" is the broad umbrella of a wide variety of techniques, circuits and systems that filter, smooth, regulate, limit, compensate and adjust AC and DC power to accomplish optimum system performance.

In the arena of removing noise, most such conditioning products <u>filter</u> noise. This means that they stop or arrest the noise. It is somewhat akin to damming a river. The problem with the filter approach (and the dam for that matter) is that the pressure is always there. There is something that is always trying to get through. There are various things that can change that will alter the effectiveness of the filter, most notably the load impedance. Simply turning loads off or on, by definition, changes the load impedance, so the effectiveness of a filter, typically varies.

Care must be taken in the design and use of filters since they frequently have high-Q circuits. This allows them to have sharp pass bands or stop bands, but has the decided disadvantage that high-Q circuits typically develop very high internal voltages. These internal voltages are Q-times the applied voltage. So a filter with a Q of 10 (not a particularly high Q) that is powered from 120 VAC, will have (10 * 120) 1200 volts AC internal to the filter. Now, moisture, dust and other debris become a problem since they can cause arcing in the filter. In addition to precipitating component breakdown, and causing a fire hazard, electrical arcs are perhaps the most powerful generator of broadband noise that mankind has ever invented.

Filters require that they <u>carry</u> the power that they are filtering. So all of the power that needs to be filtered passes through the filter. If a filter is added to a major utility power feed after the fact, it will require quite a bit of efforts to reroute the power through the filter.

1.2.3 MxDNA Approach To Conditioning Power – Removing Noise

The MxDNA (Maximum Dissipative Noise Attenuation) products are fundamentally different from a filter type of product. The basic architecture of the MxDNA is to provide a low impedance path for the high frequency noise. The MxDNA provides a "path of least resistance" for the noise. Once the MxDNA has "captured" the noise power, it dissipates it. "Dissipate" means turning the noise power into heat. This heat is radiated from the product. It is important to note that once the noise power has been turned into heat, it cannot "get back" to "electrical noise". It is gone forever.

Another important and fundamental difference in the MxDNA product architecture, is that it does not "carry" the power that it is conditioning. The MxDNA operates in parallel with the loads (equipment) that it is protecting from noise. The MxDNA simply plugs into a standard AC outlet and draws the noise on that AC line into itself – then dissipates it. This makes it especially easy and convenient to install the unit in a particular application. It also makes it very easy to test the effectiveness of the MxDNA in a particular setting.

Another important aspect of this architecture of the MxDNA is that it can be deployed in a modular fashion. If a single MxDNA does not provide sufficient reduction of noise power, more units can be plugged into the same circuit.

Finally, the intent of the MxDNA approach is to capture and remove utility noise power as early as possible. Capture it on while it is on the AC line. Capture and dissipate it before it enters the audio, or other equipment.

1.3 Acknowledgements

My brother Greg and I would like to acknowledge our friend and associate Walter Bauer of Bauer Energy Design, Inc. Walter was one of the early testers and adopters of the MxDNA system. Walter's first test of the MxDNA was in conjunction with his audiophile system. He experienced a considerable improvement in the quality and enjoyment of his system with the MxDNA in place. His remarks are paraphrased below.

I don't know if you realize what you have accomplished. This has never been done before. You have made quality improvements that I have never heard before this. You have removed an underlying smearing of sound. The drums, the piano, are so clear and crisp now. I have never heard anything like this. How does this work? What is the mechanism of producing such a clear sound? There was an underlying muddle that becomes obvious when it is removed. How did you do that?

Walter's remarks were delightful to hear. This paper will explore the analytically efforts to explain how the removal of high frequency noise can remove various low frequency noise/interference signals. Several mechanisms will be explored.

2.0 Noise/Interference Environment

2.1 Linear vs. Non-Linear Environments

Noise (or any signal) can exist in a linear or non-linear environment. To explain this as simply as possible, a linear environment (a circuit or a system) is when the voltage of a signal is increased by a certain percentage, the resulting current (from that voltage) increases by precisely the same percentage. In a non-linear environment, the current does not increase by the same percentage. In high fidelity equipment, non-linearities are, most of the time, not really our friends.

2.2 The Non-Linear Case, The Principle

Let us use music as an example of signals. Let us have a flute and a trumpet playing together. They are playing different notes, different frequencies. These notes of the instruments are the signals that we are now considering. If both of these signals are present in a linear environment, then they exist there, undisturbed by anything else. There are only those two notes. If, on the other hand, these signals are in a non-linear environment, then those non-linearities create additional signals. The frequencies of those additional frequencies are the sum and difference of the two original signal frequencies. Those additional signals are sometime called derivatives.

Example:
Trumpet signal is 440 Hz (cycles per second)
Flute signal is 1200 Hz
Sum signal is 1640 Hz (produced by the non-linearity)
Difference signal is 760 Hz (produced by the non-linearity)

In all high fidelity equipment, linearity is of paramount importance, unless there is a need for a special effect.

An example of where non-linearities are introduced in music on purpose, is the fuzz-tone used by electric guitar musicians.

The point of this discussion is that the noise signals that are present on the A.C. power line, above the 20 Khz audio upper limit, can in fact find there way into the audio range of 20 Hz to 20 Khz. As just explained, this occurs due to non-linearties.

For example, if there are two noise signals on the A.C. line at 50 khz and 53 khz respectively, then they can combine in a non-linear environment to produce signals of 3 Khz and 103 khz. The 3 khz in well within the audio range. The non-linear environment could be the A.C. power line itself, including utility transformers or, more likely, in the power supply of the audio equipment, especially the rectifiers that turn the A.C. power in to D.C. power. NOTE: almost everything electronic in the world, runs on D.C.

Once the noise is in the D.C. power supply, it can find its way into the audio amplifiers and be heard.

2.3 The Non-Linear Case, The Reality

In the previous explanation, we discussed two noise signals of 50 Khz and 53 Khz and described their combining to produce 3 Khz. In fact there are many, many signals of noise on the A.C. line, including some that are quite close to each other, in their frequency. Here is an example:
Noise signal at 50.00 khz
Noise signal at 50.02 Khz
Sum signal at 100.02 Khz (produced by the non-linearity)
Difference signal at 0.02 Khz (produced by the non-linearity)

0.02 Khz is 20 Hz.

Here, two high frequency signals, both well beyond the audio range, have combined to form a very low frequency signal. Imagine this humming, buzzing, rumbling in your audio equipment, as a sort of, underlying fabric. A fabric that you don't want.

In fact, in a non-linear environment, each signal combines with every other signal and the sum and difference is produced with each of those combinations. It produces quite a broad band noise spectrum. With the high frequency noise signals that are common on the A.C. power lines, we can expect there to be noise signals across the entire audio range, from this effect of summing and differencing signals.

2.4 The Linear Case, The Principle

2.4.1 Introduction

Any time that more than one audio signal is present in a system, there will be a composite waveform that represents all of the waves combined in a simple additive way. There are countless examples of audio waveforms adding together. An orchestra is a good example of this. Not only are there many instruments playing, each offering its own signal, but most instruments are rich in harmonics, so each instrument is actually producing many signals at different frequencies. Another common example of a composite waveform in the audio range is that of human speech. It is rich with signals at different frequencies.

The point of these examples is that these composite waveforms are heard, understood and appreciated by people. The complex nature of their content is not a problem of any sort. It is desirable. It is what is intended.

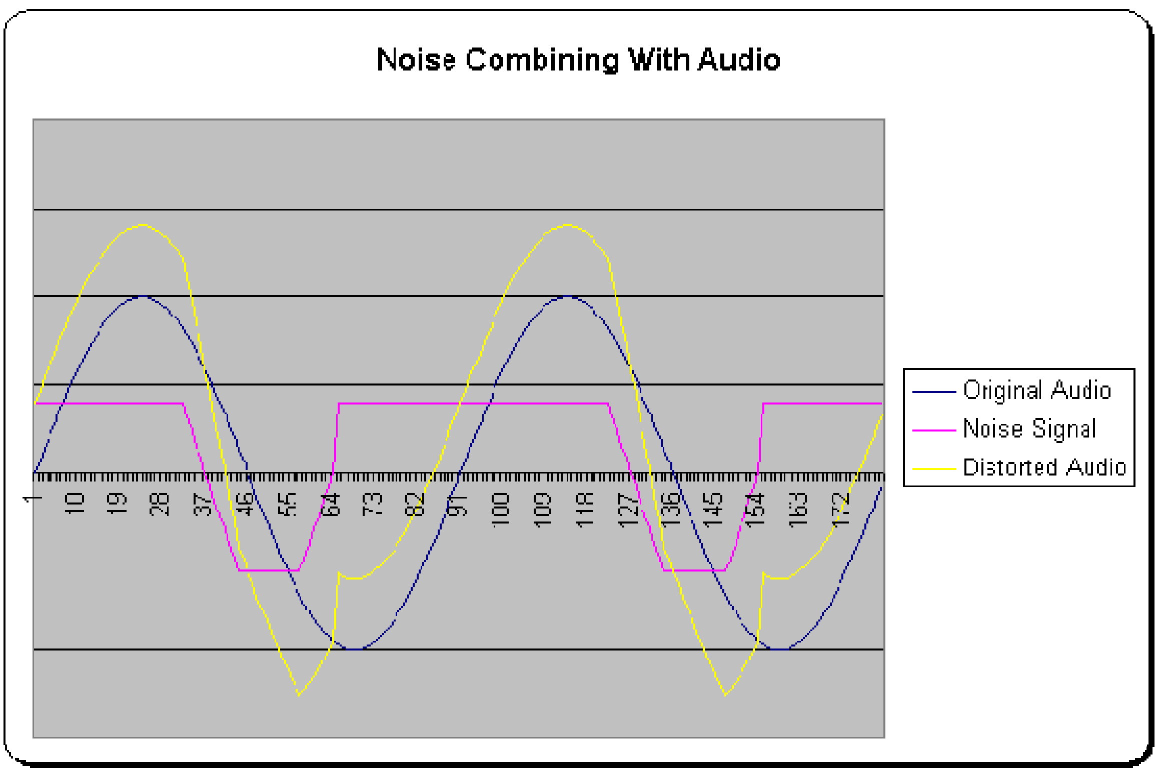
On the other hand if a complex audio waveform has constituents that are noise, i.e. constituents that were not intended to be there, then we have the obvious situation of the rendering of the complex audio waveform being unpleasant, unintelligible, not useful, etc.

2.4.1 Noise and Desired Audio

We will now consider a simple case where a pure tone, a sine wave, a desired signal, exists in a system (e.g. an audio amplifier) with a noise signal. We will call this signal the Original Audio.

The noise signal will be typical of noise produced by switch mode power supplies. There are examples of equipment that use this type of power supply mentioned earlier in this paper. The noise signal will not se a sine wave. We will call this signal, the Noise.

In the figure that follows, the Noise is smaller than the Original Audio, but there are on the same order of magnitude. In other words, the Original Audio is not 1000 times greater than the Noise. These amplitudes were chosen to represent a passage in a musical piece when the amplitude of the sound (music for instance) is low, where it is delicate.



In the figure the Original audio is seen to be a pure sine wave. The noise is closer to a square wave. The Waveform that is called the Distorted Audio is the simple combination of the Original Audio and the Noise.

2.4.2 Distorted Audio Analysis

Depending upon the frequencies of the waveforms, the listener to music with this combination of Original Audio and Noise might hear a hum, buzz, squeal or hiss. It will be present as long as the Noise is there.

An interesting view of the Distorted Audio can be had by looking at the zero crossings of the Original Audio, vs. the zero crossings of the Distorted Audio. The presence of the Noise has shifted the zero crossing in time. This change in timing is called Phase Modulation. How might it be heard by the listener? Phase Modulation and Frequency Modulation are close cousins of each other. In fact, a technique of accomplishing frequency modulation in a FM radio frequency transmitter is to apply some processing to the audio signal, then use a phase modulator circuit.

It is entirely possible that the above Distorted audio is heard by the listener as frequency modulation of the Original signal.

While there are certainly situations where frequency modulation of a note (a signal) is intentionally performed by a musician (vibrato of a note on a guitar), in general, unwanted frequency modulation will be quite undesirable.

This frequency modulation can have an effect of smearing the Original Audio. It can remove the clean and crisp rendition of the musician. For example, the crisp beat of a snare drum can sound muddy. Cymbals may seem to resonate in an unnatural way. The mellowness of a French Horn could be negatively affected. It is like there is an underlying noise fabric to the intended audio.

2.5 The Linear Case, The Reality

Some noise signals on the A.C. power line will be fairly constant. If noise is there from a personal computer that is left on 24 hours per day, then the noise from the switching power supply will be constant.

There are many noise sources that are intermittent, transient or sporadic. This will, of course cause the landscape of the Original Audio to change with time. As different noise signals are present on the A.C. line, their energy, or the energy of their derivatives will come and go.

The important point here is that a constant noise signal can be heard, identified and pointed out by the listener. On the other hand, when noise is changing, the listener may not be able to single out the changing noise, but he/she will definitely hear it. The listener may feel that something is wrong. Something is not pleasing. The listener will wonder what is it that I do not like about this rendition?

Now, if that changing landscape of noise has indeed been the experience of the listener, and then the listener installs the MxDNA product, we could expect the listener to declare that he/she is enjoying the music much more, but not be sure how to explain what is better!

3.0 Summary

This paper has focused on the use of the MxDNA product in high fidelity audio equipment environment. It has examined sources of noise and their transformation by non-linearities of various systems. Explanations have been offered on the mechanisms that high frequency noise (above the audio range) can in fact find its way into the audio range. This paper has examined certain undesirable effects that noise components can have when they manifest in a particular system.