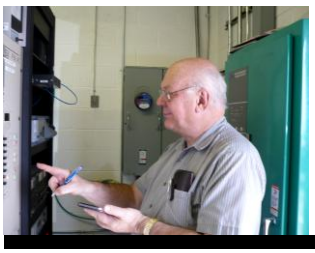

The
Broadcasters' Desktop Resource
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SOUND PROCESSING

A History of Audio Processing

Part 3 – Digital Processing Starts Making Noise

by Jim Somich
with Barry Mishkind

[May 2010] Before his untimely death, Jim Somich and I had a number of conversations by phone and email as we discussed the history of broadcast audio processing and laid the basis for this article.

Both of us had been involved in the production of the multiband processors that gave radio a loud, clean voice in the 70s and 80s, and we had watched the changes over the years, from simple levelers to the microprocessor-driven digital processors of today. Part 1 of this series focused on the first audio processors, built for transmitter protection, and ran through to the era of super modulation – where loudness was the singular goal. Part 2 focused on the era of multiband processing. This time we look as the digital revolution came to audio processing.

As in the previous installments, Jim Somich took the lead on this guided tour. I get to help finish it off as a tribute to a great radio engineer.

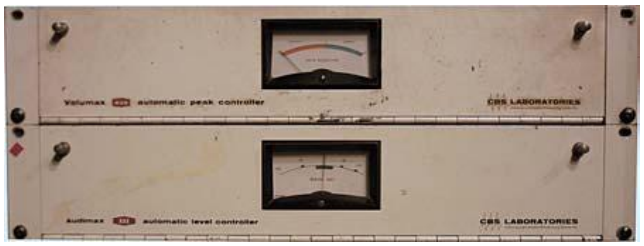
What will it take to develop the next generation of audio processors? We surely do not have the answers today. In fact, we do not even know many of the questions. But let us give it a try!

THE LATEST AND GREATEST

The 1990s brought a significant change to audio processing – digital circuitry was rapidly replacing analog audio control. Some of the old names could not or would not make the transition and became "history." Sadly some real sharp engineers, like Ron Jones and Steve Hnat succumbed to early deaths.

But some new names began to join the established pioneers in audio processing, taking advantage of the digital revolution do some amazing things to audio.

Nevertheless, stop for a moment and consider: As we look back at the Audimaxes and Sta-Levels of the past decades, it is easy to remember all of their various shortcomings in handling audio. It is easy to assure ourselves that our modern processors using digital techniques are "state-of-the art" all the way. After all, digital is perfect is it not? And we do have digital boxes, do we not?



Should we recall the Maxx Brothers with respect
… or laugh at them in comparison to today's units?

Yet, it is important that we do not embrace digital just because it is digital. Many analog designs from the past are still performing exceptionally well on the air, proving that you do not need the latest digital box to sound great.

Well, perhaps it is time to break an egg or three: I predict that in thirty years we will look back on the DSP processors of today in much the same way as we smile condescendingly at the mention of those Maxx Brothers and their cousins of yesteryear.

"History Repeats Itself. First as tragedy, then as farce." – Karl Marx

IS DIGITAL REALLY BETTER?

It is a fair question. Digitally controlled audio can sound great. Digital control permits broadcasters to accomplish with ease digital strategies that were virtually impossible in the analog world. Nevertheless, as we look at all the power DSP brings to the table, a valid question arises: Why is it that modern radio really does not sound all that good?

The answer actually is fairly simple: as with any tool, digital audio processors can be abused. In the hands of a true audio craftsman, great audio happens. On the other hand, in the hands of someone who merely wants to be loud, these high-tech tools can create audio that will make ears cringe.

My hope is that when you understand the techniques developed, your appreciation for the tool will incite you to think about and produce great audio.

DIGITAL'S DAY DAWNS

Most stations that have the budget and can afford to buy anything they want are using either Orban or Omnia digital processors. Each box has its own unique processing strategy - based on the best analog designs of the past – and making significant enhancements and improvements on the older designs.

The advent of DSP (digital) finally brought the industry to the pinnacle of processor performance. It is interesting to note that at each step we often thought we knew all there was to know about the art of audio processing. Fortunately, there was always someone who would not take that for granted.

Indeed, even while some feel we may have reached the limits of what can be done with audio, breakthrough processors continue to be unveiled.

The 1990s developed into an exciting time for audio processing. Change was all around. Frank Foti left Z-100 and returned to Cleveland to strike out on his own building processors. Bob Orban had partnered with Greg Ogonowski to design the next generation of audio processing. Even the Europeans were bringing new products to market.

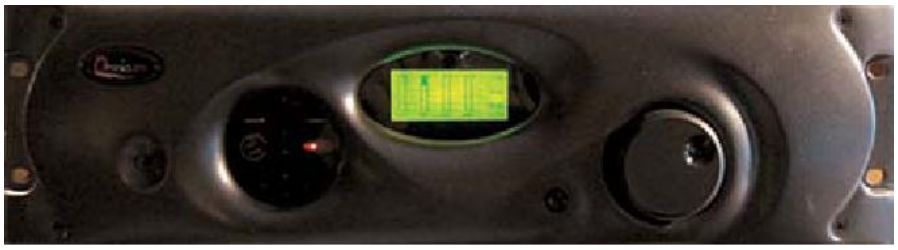
History buffs might enjoy some additional reading on the evolution of audio processors. Here are two good papers for you to check out: www.omniaaudio.com/tech/retrospective.htm contains Frank Foti's thoughts. Bob Orban also tackled the subject in 1992. His paper is at: www.bext.com/histproc.htm

DIGITAL CONTROL ARRIVES

Foti's first commercial processor was the Unity 2000, an analog box that incorporated every trick the master had learned at Z-100 and WMMS. It was a bit hit and a terrific launch product for his new company, Cutting Edge Technologies.

The Unity 2000

But more change was in store for Foti as, in the early 1990s, he joined forces with his best friend and DSP guru Steve Church, to bring his new vision to life – a digital processor they called the Omnia!



The first Omnia

The Omnia was a unique vision, born in the trenches of New York City radio and nursed to life by a DSP genius and a processing warrior. It is no wonder that the Omnia has been the most popular processor in the New York City market.

Meanwhile, the "Bob and Greg Show" out in California was not letting moss grow beneath their feet either. The 8100A was aging, and Orban and Ogonowski had digital control on their minds. It was time to replace the popular 8100A.

This super-charged pair of engineers really fired off the revolution. The digital Optimod 8200 was the first Digital Signal Processing (DSP) audio processor to achieve commercial success - designed and built by pioneers of analog processor design.

The Optimod 8200

IN THEIR OWN WORDS

It is very interesting to hear what it was that drove the different approaches to audio processing. As we saw in the last part, for example, the Texar Audio Prisms were developed largely out of the pressure to counter a new processor at a competing station.

It seems to me that one of the best ways to understand the philosophy behind each processing line was to speak with the designers themselves. Although the keen competition amongst the manufacturers tends to keep the top guys from divulging key aspects, a chance to sit down and talk with them gives one a much greater appreciation for what goes into taking program audio and making it ready for the transmitter. I am sure you will be as fascinated as I was by what they had to day.

In preparing this material, we were fortunate to be able to interview Bob Orban and Frank Foti, living legends in the processing world, and Cornelius Gould, a young turk who might well be the contemporary face of the processing designers on the cutting edge of the technology. These three guys are among the best-placed to give us insights not only into the current state of audio processing - but into what we can expect in the years ahead.

Given the packed schedules of most everyone today, you will understand that the following conversations were a combination of live, email and telephone conversations. If we listen carefully and are fortunate, we might learn something from these guys.

THE PROCESSING "LIGHT" GOES ON

Jim Somich: Frank, while some people think you were an "overnight success," I know you really exemplify being on a path of learning, experimenting, and finally, after a lot of hard work, succeeding in your goals. Who and what influenced you as you worked your way up to your first processor, the Vigilante?

Frank Foti: During my stint at Z-100 (1983 to 1987) we had the Texar Audio Prisms. Up until that time, FM audio processors generally employed pre-emphasis before the (multiband) limiters.

Upon grasping the full understanding about how that multi-band system worked, I kept thinking about a limiter system that managed pre-emphasis after the multi-bands, rather than before them. My thinking was that the control loops in that architecture were essentially tilted upwards a bit, due to the emphasis, and that was causing uneven processing in the upper frequencies. Essentially the upper range of each audio band had a lower limiting threshold.

The question – and quest – became finding out what happens if the control

loops are flat and the limiters are set to manage pre-emphasis via differing threshold levels.

BUILDING ON WHAT CAME BEFORE

Jim Somich: Your first processor was actually an adaptation of an existing processor, was it not?

Frank Foti: The Vigilante grew out of the Aphex Dominator, Model 700. I had seen the prototype Dominator at NAB 1985, but it was a lot more elaborate than the finished product. The prototype appeared to be a direct answer to the Orban Optimod 8100, but with auto-adjusting crossover frequencies, and a few other new tricks. I never knew why that version never appeared.

However, upon playing with the original Dominator – which sounded very good if not pushed too hard – it became apparent that the timing was the same in all three bands. That caused the unit to become "busy" sounding quite rapidly, especially when set aggressively. Before ever having a schematic at hand, I found the R-C networks that governed the timing and began playing. It did not take long to "tune" the unit for a CHR station.

Eventually, a schematic was acquired. I began playing with the ALT (Automatic Limiting Threshold) circuit and more advancement in the Vigilante's gestation occurred. Being able to modify the threshold settings in the Dominator empowered the box to manage pre-empha-sis very consistently.

The Cutting Edge Vigilante

The "attack" and "release" functions were brought out to the front panel via three-position switches. The limiting thresholds were also brought out via numeric "dial pots" that, in fact, were suggested to me by you! But the key sonic element - and improvement that we heard on-the-air - was how much the high frequency domain opened up. This was the result of pre-emphasis insertion after the multi-bands.

GETTING TO THE CUTTING EDGE

Jim Somich: Was the Vigilante a complete, all-in-one, stand-alone box or did it require support by other processors?

Frank Foti: At this early stage the unit only did the dynamic limiting. We used the clippers (cards 8/9) from the Orban 8100, which worked quite well. Upon launching "Cutting Edge," and building these full-time, radio stations wanted an integrated solution; I designed our first distortion-controlled clipper, which was added to the Vigilante sometime in 1989.

Jim Somich: Which processor designers influenced you most strongly at this time?

Frank Foti: The influence here was mainly Glen Clark. I thought his Audio Prism concept to be very good. I used to tell him that he needed to create a multi-band limiter version of the Prism. While the Dominator was multi-band, that was not the idea that was lurking in my head. Upon the modifications to the Dominator, it got closer, but those ideas eventually manifested themselves in the Unity – and eventually in the Omnia.

CREATING UNITY

Jim Somich: OK, that progression makes sense. Now what was the Unity, and how did it differ from the Vigilante?

Frank Foti: The Unity was our attempt at putting the rack of individual processor units in one box. The technology used was known as "digitally-sampled analog." The idea was to clone a rack of gear that would have been a wideband AGC, multi-band compression, multi-band limiting, pre-emphasis, distortion controlled clipping, and the stereo generator. It worked quite well.

The Cutting Edge Unity 2000

The clipper design came right from the Vigilante. The stereo generator included a composite clipper that performed clipping before the pilot was inserted. The entire system was governed by a microprocessor; it could save and recall a default, as well as user presets.

A concept we introduced with Unity, and carried forward to Omnia, was the idea to employ differing architecture into the dynamic sections. The Unity had feedback control on the lower two limiters and feed-forward on the upper two bands. This enabled the system to maintain the warm IMD-ish sound on lower frequencies, which feedback limiters tend to offer.

Jim Somich: That approach is a sort of double-edge sword, right? IMD is not normally a desirable audio component.

Frank Foti: That is true. IMD is quite irritating on "presence" and "high" frequencies. On those bands, we utilized feed-forward control, which is inherently much lower in IMD. This type of processing offers a clean, open, and smooth high end, while retaining a rich fullness to the low end. We still use this method within Omnia processors.

Jim Somich: If you were asked to point out the main weakness of the Unity, what would that be?

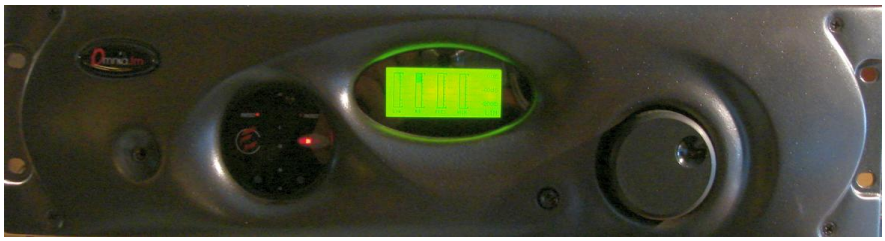
Frank Foti: In hindsight, the Unity never had the internal flexibility that a DSP box has. As such, there were many hindering factors that kept me from getting it to where the ideas that were still lingering up in the foggy grey matter needed to go.

Of course the Unity was successful enough in that it made the worldwide broadcast industry aware of our efforts. If anything, it got the company noticed when we introduced the Omnia, which was our first full DSP processor.

DSP AND THE OMNIA

Jim Somich: Frank, how did your first DSP processor, the Omnia come about?

Frank Foti: Omnia was an outgrowth of the Unity, along with input from all those who were critical of the Unity. Moving into DSP illuminated many things for us; most notably was the whole notion about how to clip pre-emphasized audio without causing aliasing distortion. Steve Church and I put a solid two years into researching that one alone.



The Original Omnia.fm

Omnia's lineage follows my thinking all the way back to Z-100 and the rack of gear we had in NYC. The first goal – and what would have been the deal-breaker – was to create a hard-limiter (clipper) that didn't generate that awful grunge effect that was obvious to the sound of other units and was giving DSP-based processing a bad name.

Within the dynamic sections, we were able to take advantage of the DSP processing power to add functions like "Make-Up Gain." This allows the compressors to operate with slower overall timing, but "knows" when softer segments are occurring and will speed up the system only during those intervals.

Additionally, Omnia offers gating that is very intelligent. It can reset the dynamic gain to a preset platform level or just freeze gain during periods of gating. Stereo-EFX was designed to enhance stereo without destroying the natural sound field or exaggerate multipath due increased RMS levels of the L-R signal.

The composite clipper that is incorporated into Omnia also contains a DSP version of "The Dividend" which keeps composite clipping products in the SCA region down to a minimum. This was a first for an integrated audio processor.

Jim Somich: Once you had a working prototype, how did you introduce it?

Frank Foti: I personally took the beta version of Omnia.fm to those customers who were not fans of the Unity. I figured if we could please the critics, then we were on to something. With all honesty, I can say that we visited close to 25 customers (the world over) - and every one of them purchased the Omnia!

Jim Somich: That is quite an achievement for any product! So, looking ahead – can I get any predict-tions from you? What can we expect out of you and your team in the future?

Frank Foti: Looking into the future is always fun. We now live in a coded-audio world. Thus, audio processing is becoming more focused on that transmission method. Still, I feel there's still at least one more, if not two, conventional broadcast processors yet to be designed for FM and AM (at least from our company). I'm not sure that those will be focused on more loudness. As we all know, processing creates LOUD audio today, all the way from the CD source straight through to the eardrum.

We will employ algorithms that will diagnose the signal and modify the architecture in order to reduce sonic artifacts. (We're doing this already in the codec world with our SENSUS Technology.) Reduction of distortion, THD, and IMD, while maintaining competitive audio is the goal. Then again, hasn't that always been the goal?

We're moving towards a transition period from where we have dedicated boxes into the early stages of doing all processing as a PC application. We have already developed a processing farm where many instances of an audio processing application are operating within one "engine" – a single box that allows up to a preset number of audio processors to run independently of one another. I/O is Ethernet to the station's infrastructure or can be routed to dedicated nodes that are AES or analog.

Utility functions regarding processing are becoming more elaborate; the ability to display detailed information about a signal, or segment thereof, is now available. Processing power, which once was a premium in cost, is now quite affordable in the digital domain, just as the lower-cost, high-performance opamps and VCA's became during the analog years.

Jim Somich: Thank you, Frank. Talking with you is always an education.

As we continue this walk through processing history, we will talk next with Bob Orban…. Stay tuned!!!

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The History of Audio Processing - PART 1

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