Audio Processing in Digital Audio Broadcasting

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The future of radio emission technology appears to be digital. Throughout much of the world, the Eureka-147 has been adopted as the technical standard, providing the potential for near CD-quality audio and offering ancillary data services.

Broadcasters have been accustomed to processing audio for AM and FM transmission with transmission audio processors like Orban's Optimod series. These processors compress dynamic range to make the signal comfortably listenable in noisy environments, and also to make the best use of the dynamic range limitations of the channel itself. In analog services, this dynamic range varies as a function of reception conditions, being poorest in the fringes. Audio processing therefore also increases the potential coverage area of analog transmissions.

Digital transmissions behave differently. The technical specifications of the transmission system determine the signal to noise ratio, and does this not change with signal strength. Although various strategies have been used to permit so-called "graceful degradation" at the edges of the coverage area, digital reception is largely an "all-or-nothing" proposition.

What role does audio processing play in a system with a very low noise floor? It still can have several vital functions:

- First is dynamic range compression to accommodate the signal into typical listening environments like autos and homes. In autos, the acoustic dynamic range is severely limited by wind and road noise. In most apartments and multi-family dwellings, the available dynamic range is limited by the need to avoid disturbing family and neighbors with excessive sound levels. There are relatively few environments where the full, uncompressed dynamic range of the original program material is useable, or desirable.

- Second is to ensure a consistent presentation. In radio, program material from different producers is constantly juxtaposed. Yet most successful broadcasters agree that achieving a "major market" sonic image requires an overall consistency of sound texture and spectral balance from source to source. Multiband compression can achieve this. By setting a target spectral balance and automatically re-equalizing program material that does not have this balance, the multiband compression helps the radio station achieve a "big-time," highly produced sound that sounds authoritative to listeners.

- Third is to reduce the peak-to-average ratio of the signal to increase its relative loudness by comparison to an unprocessed signal normalized to the same peak level. In the Eureka system, a number of signals share the same "multiplex ensemble." Each signal in the ensemble has exactly the same reach. So the only thing that broadcaster can do to stand out from his neighbors (and possible competitors in a given multiplex) is to broadcast a louder and punchier audio signal. Experience has shown that a combination of multiband compression and sophisticated peak limiting is the most effective way to do this.

- The final function is helping to improve the intelligibility of substandard program material, particularly news actualities and incoming telephone calls. Properly designed multiband compression like that used in Orban's Optimods can make startling improvements in this material without need for preprocessing in a production studio.

All of these functions apply just as well to digital radio as to analog radio. However, we should also consider another complication. The Eureka-147 system offers a function called Dynamic Range Control, or "DRC." This allows embedding gain information in the digital bitstream that allows dynamic compression to occur at the receiver. However, the DRC signal implements only wideband compression, which has been obsolete in broadcast transmission processing for at least 20 years. Wideband compression cannot perform the automatic equalization function needed to ensure a consistent presentation. It cannot be used to aggressively increase loudness because the bass will pump the midrange, which is a problem called "spectral gain intermodulation." In short, a station cannot use the DRC system to create a sound at the receiver that is processed to the standards and expectations of modern competitive broadcasters. Accordingly, we see DRC as being useful mainly for certain niche formats such as classical music, where a wide dynamic range is important to the artistic content of the program.

Let me now describe Orban's processors for DAB—Optimod-DAB 6200 and the Optimod PC-1100 which incorporates the digital audio processing from the Optimod 6200s on a PCI sound card. The processing is the same for both products and as such, this discussion will center on the 6200 in the DAB arena as the 1100 was specifically developed for the needs of webcasters and Internet only broadcasters. The 6200 offers three different processing structures, only one of which can be on the air at a time:

- The five-band structure is appropriate for most broadcasters, particularly those programming popular music formats, news, or sports. This structure is very effective in ensuring a consistent presentation because of its powerful ability to automatically re-equalize program material to a standard. It is also the most effective structure for the broadcaster who is competing against others in his multiplex on the basis of loudness and punch.

- The two-band structure is appropriate for broadcasters who want to remain true to the timbral content of the original program material, while still applying a tasteful amount of compression. It is particularly useful for classical and jazz material because it retains the spectral balance of this material without re-equalizing it except to provide gentle correction of bass balances.

- Finally, the Protect structure is designed to be used below threshold most of the time, and to provide gain reduction only when the operator sets levels too high. Functionally, it is a transmission limiter that prevents channel overload while not affecting program material whose levels are already correct.

Except for Protect, all structures consist of the following elements in series:

- First, a slow AGC rides gain over a range of 25dB. This evens out inconsistent input levels and drives the subsequent processing in its "sweet spot."

- Second, a multistage program equalizer allows the broadcaster to color the sound to create a "signature sound" for the station. The equalizer offers two fully parametric sections for midrange and treble, and a special shelving bass equalizer that can provide either 12dB per octave or 18dB per octave slopes. This allows considerable bass punch without over-equalizing mid-bass, which could otherwise create a muddy, boomy quality.

- Third, a multiband compressor with either two or five bands does most of the work in reducing the dynamic range of the signal with minimal undesirable artifacts.

- Finally, a fast look-ahead peak limiter effectively reduces the short-term peak-to-average ratio of the signal without clipping. Unlike a clipper, this limiter does not create wideband modulation distortion throughout the audio range. This is very important in digital broadcasting because this wideband "trash" can unnecessarily stress the Eureka-147's MPEG1 Layer 2 perceptual encoder by forcing it to encode spectral energy that was not present in the original source material. It therefore has fewer bits left over to encode the desired material, and quality can suffer. By preventing this problem, the 6200's look-ahead limiter maximizes the quality available for a given bit rate.

The 6200's internal sample rate is 48kHz and its audio bandwidth is 20kHz. Except for the equalizers, which provide analog-style minimum-phase characteristics, all processing is phase-linear, including the multiband compression. This maximizes audible transparency.

The 6200 provides AES/EBU digital inputs and outputs standard. Both inputs and outputs are equipped with sample rate converters and can accept and emit 32kHz, 44.1, and 48kHz rates. At its native 48kHz sample rate, the output's overshoot is less than one-tenth of a dB, which ensures the most competitive possible loudness. There is also a low-overshoot analog output, which is intended mainly for monitoring but which has high enough quality to use on-air if a digital link between the 6200 and the transmitter is unavailable. Finally, an AES/EBU sync input allows the system designer to ensure that the 6200's output sample rate is locked to house sync even if the digital input is asynchronous.

The 6200 can be remote controlled, either from a PC running Orban's Windows-based remote control software, or directly from contact closures. This can solve many system design problems because the 6200 can then be located at the transmitter and can be controlled and adjusted from the studio. Any of the 6200's 32 factory presets or user presets can be recalled by remote control to day-part processing. Using the PC remote software, any preset can be edited at the one-knob LESS/MORE level, or at the FULL CONTROL level, and can then be stored in a user preset for recall at any time. Of course, this editing can also occur directly from the 6200's front panel, which uses a soft-key-based menu system and rotary encoder for easy navigation and adjustment.

Conclusion

Orban believes that the requirements for sound processing in digital broadcasting have many similarities to sound processing for analog FM. Digital broadcasting has not obviated the need for a consistent, comfortably-listenable, "produced" sound that attracts listeners and helps broadcasters compete. Experience in analog FM has shown that advanced multiband processing effectively delivers the required quality. Now, Orban's 6200 brings this style of processing to digital broadcasters with the most transparent possible signal path and full 20kHz audio bandwidth. It also offers many convenience features that facilitate its smooth incorporation into the digital transmission plant, and comes pre-programmed with processing presets that complement any program format. In the past, Optimods have been powerful tools that helped build market-dominating analog radio stations, and we believe that this will also be true in the era of digital broadcasting.