Processing for HD Digital Radio
(The "System Formerly Known as IBOC")

By Robert Orban
Vice President, Chief Engineer
Orban/CRL

The HD Radio system generates a digital carrier that shares a given station's allocated bandwidth with the normal analog FM carrier. The receiver crossfades between the analog and digital channels to minimize the effect of RF dropouts. This scheme requires audio processing for the two channels to be closely matched in texture to ensure that the receiver's crossfades are seamless.

Optimum peak limiting for the two channels is very different. The analog channel requires state-of-the-art pre-emphasis limiting to achieve competitive loudness and minimize pre-emphasis-induced high frequency loss. This usually implies use of sophisticated distortion-canceled clipping. The digital channel, on the other hand, has no pre-emphasis but is heavily bit-reduced (to 96 kbps) with the PAC perceptual codec. This creates an entirely different set of requirements: the peak limiting must not use clipping because there is no bit budget available to encode clipping-induced distortion products. However, pre-emphasis limiting is unnecessary. The best technology for peak limiting the digital channel is therefore look-ahead limiting, which can perform very clean peak reduction on flat channels, but which is unsuitable for pre-emphasized channels.

Orban's solution to this dilemma is the 8400HD FM: a single box processor where AGC, stereo enhancement, equalization, and multiband compression/limiting are shared between the two channels. Because these elements are mainly responsible for the station's signature sound texture, this ensures that the analog and digital channels will crossfade gracefully regardless of the processor's settings—great news for stations that daypart their processing.

After this processing, the signal splits off into two paths. The analog signal receives pre-emphasis processing and the digital signal receives look-ahead limiting. Although this means that the digital signal is limited to 15 kHz audio bandwidth, this is actually a plus because it reduces codec artifacts. While the codec used in the High Definition Radio system can provide a satisfying experience for the consumer, at 96 kbps it is not audibly transparent—transparency would require a higher bit-rate. By not wasting bits encoding the 15-20 kHz frequency range (which contains little useful information and which few radio listeners can hear), the codec instead provides higher quality encoding of the crucial 20-15,000 Hz band.

The digital processing chain also allows the station to insert a high frequency shelving equalizer either before or after the look-ahead limiter. Inserted before, it can reduce codec artifacts caused by excessive brightness in the previous processing. (This brightness is frequently introduced to compensate for HF limiter-induced roll offs in the analog chain.) Inserted after, it can realize the same advantage and reduce codec-induced overshoot too.

Auditioned directly, the 8400HD FM's digital output sounds dramatically cleaner and more open than its FM output, particularly in the high frequencies—it's obvious just how badly the analog channel is handicapped by the standard 75 microsecond pre-emphasis curve, which severely

compromises its high frequency headroom. Using program material, we've measured as much a 12 dB difference in favor of the digital channel at high frequencies! Even after the digital signal passes through the 96 kbps codec, a significant amount of this audible superiority remains—the HD Radio system really *does* provide noticeably better sound to the consumer.

The first-generation iBiquity exciter requires 44.1 kHz AES/EBU audio streams for both the analog and digital inputs. The sample rates for both streams must be identical. This requires two AES/EBU outputs from a single-box processor, both of which can be genlocked to an external AES reference signal. Orban's 8400HD FM meets these requirements because it realizes its HD processing as an additional hardware module that adds the necessary second digital output and sync reference input.