orban White Paper

Measuring the Improvements in Optimod-FM 8600's FM Peak Limiting Technology

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Introduction

Optimod-FM 8600 is Orban's flagship processor and the next step beyond the Optimod-FM 8500. Developed over several years starting in 2007, the 8600 offers new peak limiter technology that decreases distortion while increasing transient punch and high frequency power handling capacity. Compared to the FM-channel peak limiter in Optimod-FM 8500, the new peak limiter typically provides 2.5 to 3 dB more power at high frequencies, which minimizes audible HF loss caused by preemphasis limiting. Drums and percussion cut through the mix. Highs are airy. "Problem material" that used to cause audible distortion is handled cleanly.

While this design offers about the same loudness as 8500 processing, its main goal is to make FM analog broadcasts more competitive with the cleanliness, punch, and open high frequencies of the digital media against which FM analog transmissions now battle.

The 8600's "MX" technology peak limiter consists of two main stages—first, a prelimiter stage to control low frequency and high frequency peaks ahead of the main peak limiter and then the main peak limiter, which uses various proprietary techniques to control distortion, minimize transient loss, and minimize high frequency loss.

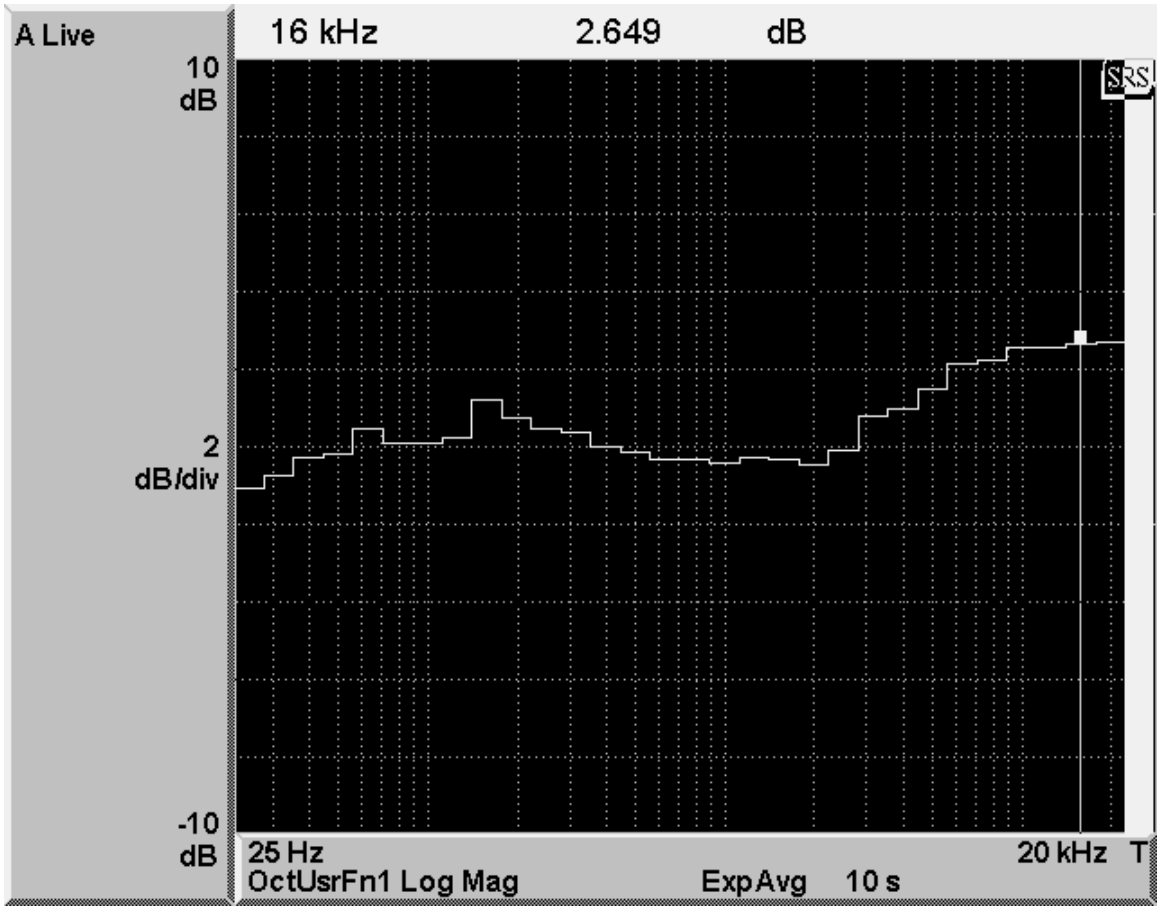

Figure 1
Madonna, "Get Together" remix; third-octave difference

Measurements

The improved performance of the MX peak limiter can be verified by objective measurements with real-world program material. To measure the improvements in high frequency power handling capability and dynamic distortion, we use a Stanford Research Systems SR785 Two-Channel Dynamic Signal Analyzer (Figure 6 on page 7) to compare the 8500 and 8600. This analyzer has two filterbanks[1] and allows the two third-octave or twelfth-octave spectra (measured in decibel units) to be subtracted in real time. The difference shows the difference in the output spectra of the two units under test, measured in dB.

Unless otherwise indicated, the measurements were made using the GREGG MX preset in the 8600 and the GREGG preset in the 8500. These presets have essentially identical loudness and are designed to have similar spectral balance in the mid-

[1] ANSI standard S1.11- 1986, Order 3, Type 1-D

range frequencies and below. A higher reading in a given frequency band indicates that that band has more power in the 8600 output than in the 8500 output.

HF Power Handling: Figure 1 on page 2 show a typical HF improvement: about 2.6 dB more average HF energy using the new technology. (Coincidentally, there happens to be about 1 dB more energy in the 160 Hz band but this can easily be matched more closely if the user wants.)

Distortion Control: In 1977, Orban was the first company to patent[2] and commercialize a psychoacoustic model to estimate and control audible clipping distortion. The 8600 also uses a psychoacoustic model, but in a far more sophisticated way that has some similarities to audio codec technology.

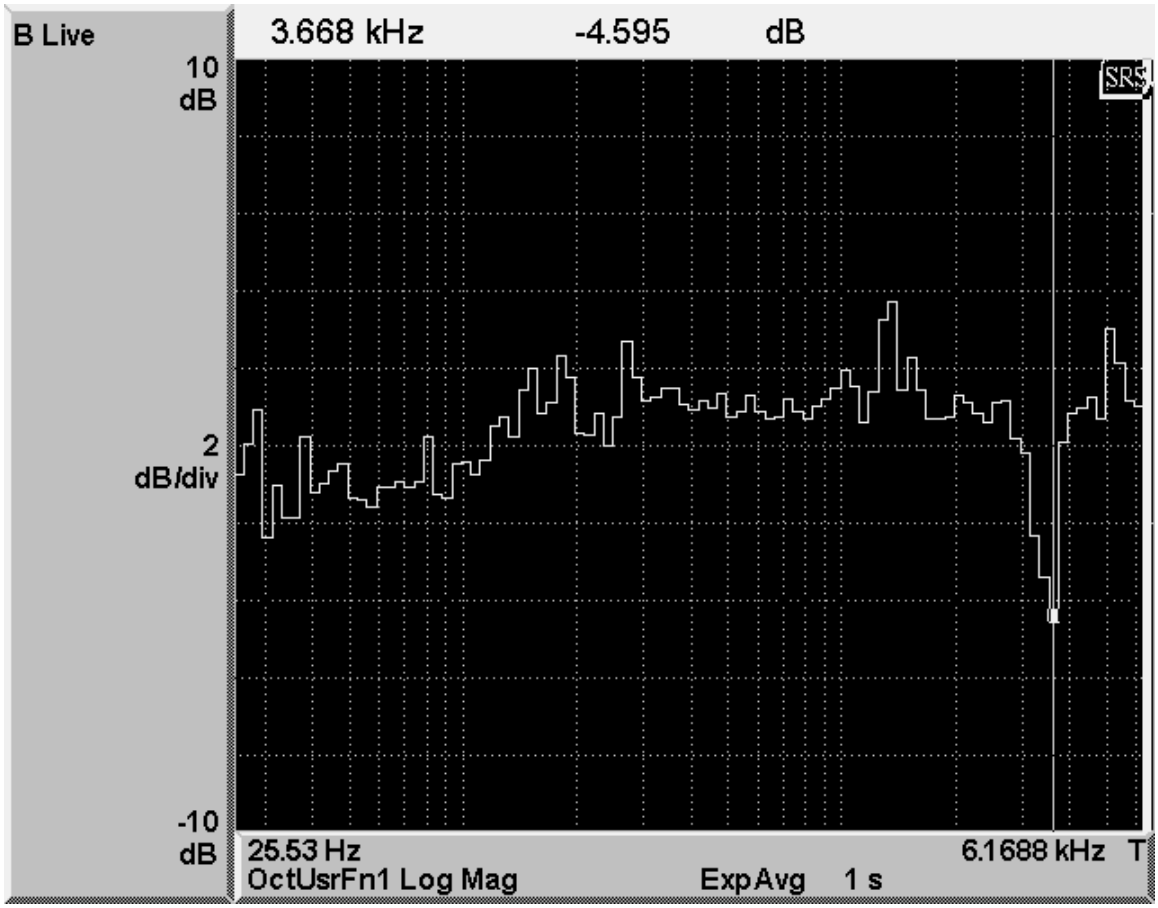

Figure 2
U2, "Within You Without You"

[2] US patents 4,208,548 & 4,241,266, used in Optimod-AM 9000A

Figure 2 is a twelfth-octave ratio that compares the spectrum of the 8500 and 8600 outputs in a more detailed way than the third-octave ratio seen in Figure 1. It shows the 8600's 4.6 dB suppression of (mainly harmonic) clipping distortion centered at 3.668 kHz caused by sustained electric guitar riding on top of bass.

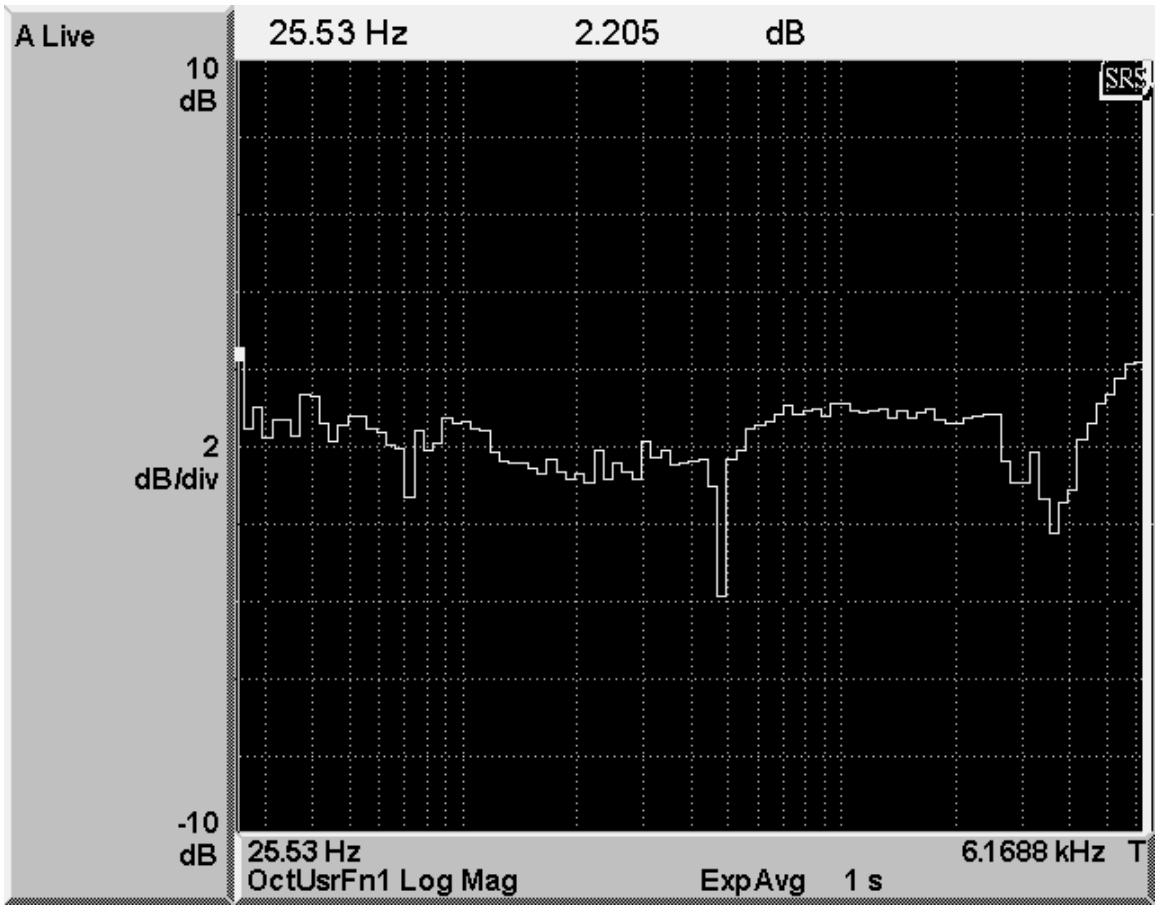

Figure 3
Kelly Clarkson, "Because of You" opening

Figure 3 shows a piece of material that has been used by others to demonstrate distortion control. This material consists of Clarkson's humming over a quiet piano background. There is little program energy in the upper midrange, so any clipper-induced distortion tends to stand out.

The twelfth-octave ratio shows as much as 4 dB suppression of narrowband difference-frequency IM distortion in the midrange. To cause the 8500 to produce noticeable distortion, we used the IMPACT preset, which is a louder preset than GREGG or GREGG MX. To keep the comparison "apples and apples," we used the IMPACT MX preset in the 8600. Even with these presets, the distortion in either Orban processor was negligible compared to the effect of even modest multipath and considerably less than certain other non-Orban processors produce with this material. (Note that the increase in the output starting slightly above 6 kHz does

not represent distortion but is instead another manifestation of the 8600's better HF power handling capability, which we first presented in Figure 1.)

Figure 4 shows an example of program material with much more energy above 6 kHz than in the midrange, making difference-frequency intermodulation in the midrange easily audible. Although other, non-distorted material in the midrange makes the measurement less dramatic compared to the previous pictures, the combination of improved HF response (about 2 dB) and midrange IM suppression is plainly visible and very audible in the 8600.

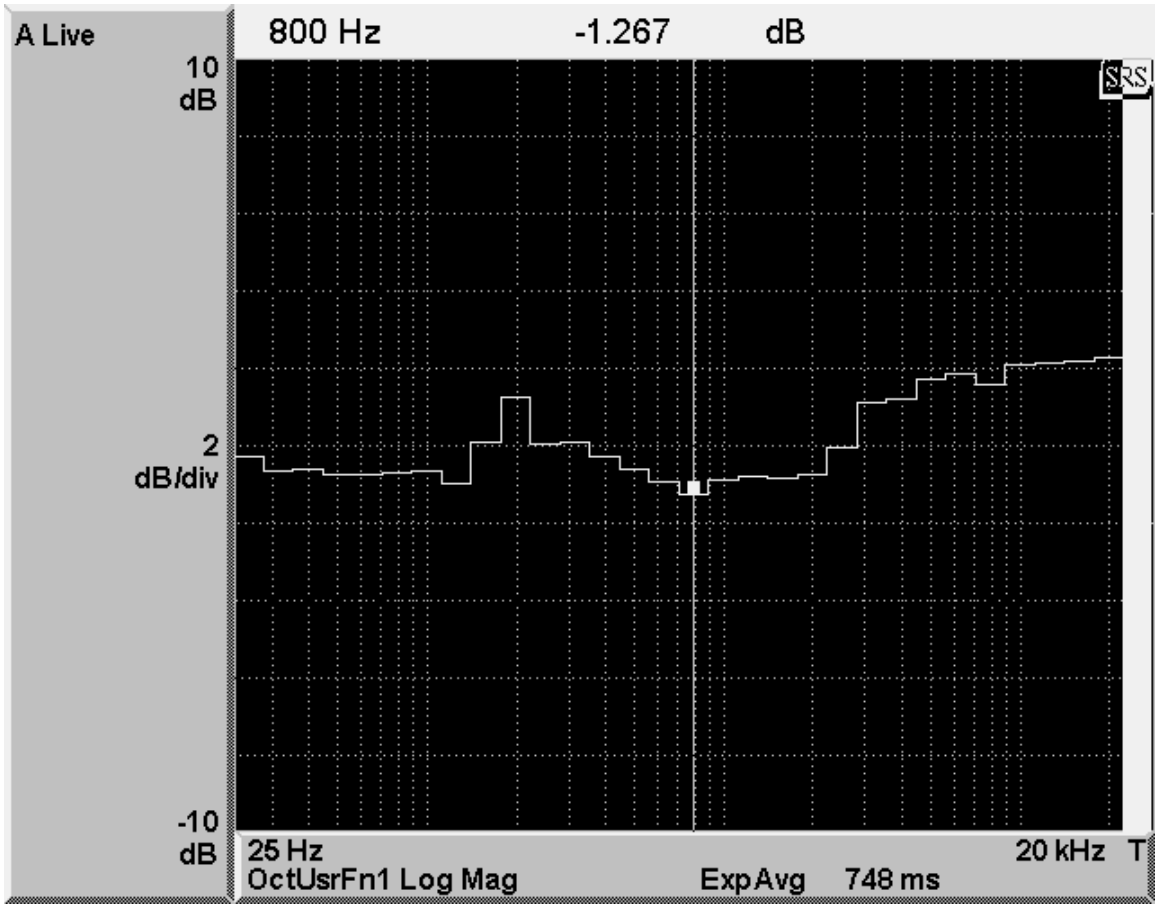

Figure 4
Level 42, "Starchild"

Transient Punch: Decreasing distortion often comes at the expense of decreased transient punch because in competitively processed FM, transients must be clipped and may therefore appear incorrectly to the distortion controller as "distortion" that requires suppression. By using sophisticated signal processing, the MX limiter not only avoids this problem but improves transient punch compared to the older technology.

The center of Figure 5 (under the small orange triangle) shows a snare drum hit from Simple Minds, "Alive and Kicking." The original CD dates from the days before "hypercompression" in mastering ruined the sound of most CDs; the snare drum has plenty of peak level. The new limiter preserves the transient (center of the screen) about 3 dB more effectively than does the old technology (bottom).

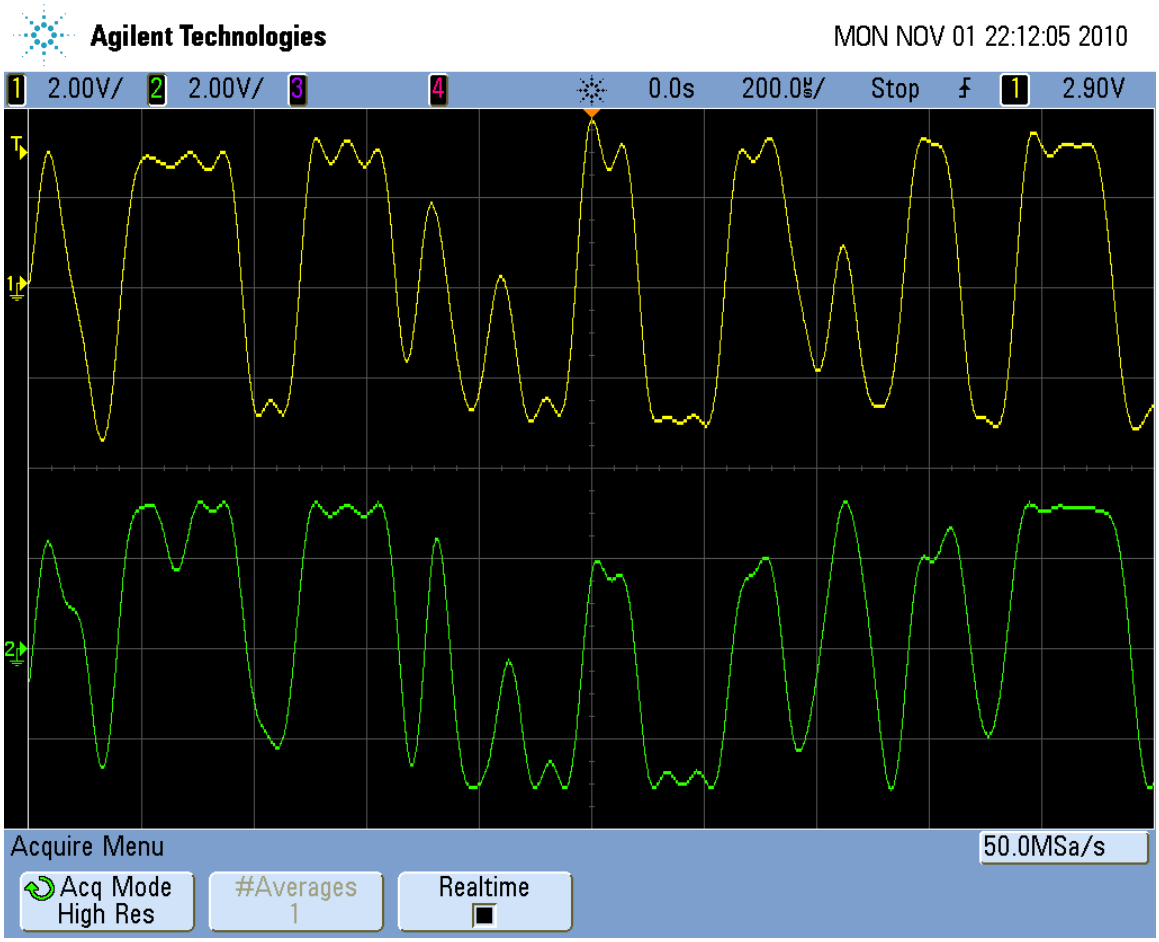

Figure 5
Simple Minds, "Alive and Kicking"

User Controls in the New Peak Limiter

The controls affecting the 8600's peak limiter allow users to trade off loudness, distortion, and bass energy. Because the laws of physics apply to MX technology, increasing bass increases the likelihood that audible IM distortion between bass and other program elements will occur. Depending on a user's station's format, users may prefer to have a cleaner sound (with less bass) or a sound with more distortion but punchier bass. We offer controls, explained below, that allow users to make this tradeoff.

Peak Limiter Drive determines the level applied to the MX peak limiter and thus how much peak reduction the peak limiter must do. The MX peak limiter uses a variety of tactics to adapt its operation intelligently to the program material applied to it. Compared to the 8500-style peak limiter, the MX peak limiter produces a different set of artifacts when overdriven. Depending on how users set the other controls, these artifacts may include loss of bass punch, harsh clipping distortion, "soft" IM distortion, and/or excessive density that can cause fatigue. If users intend to make adjustments at the intermediate or advanced levels, it is wise for them to familiarize themselves with these artifacts by purposely overdriving the peak limiter via the PEAK LIMITER DRIVE control and listening to what happens with different types of program material.

This control's range is ±6 dB relative to an arbitrary 0 dB setting that provides a competitively loud sound without objectionable distortion on most program material. Settings above 0 dB are likely to produce objectionable distortion with some program material, while settings below 0 dB trade off lower loudness for a cleaner sound.

Bass PreLimit Mode allows users to operate the bass pre-limiter in MEDIUM mode, which produces some low-order harmonic distortion below 100 Hz, SOFT mode, which produces essentially no harmonic distortion but may reduce bass punch compared to MEDIUM mode, or HARD mode, which produces the most distortion but also the most punch. The modes are very similar to the SOFT and MEDIUM bass clipper

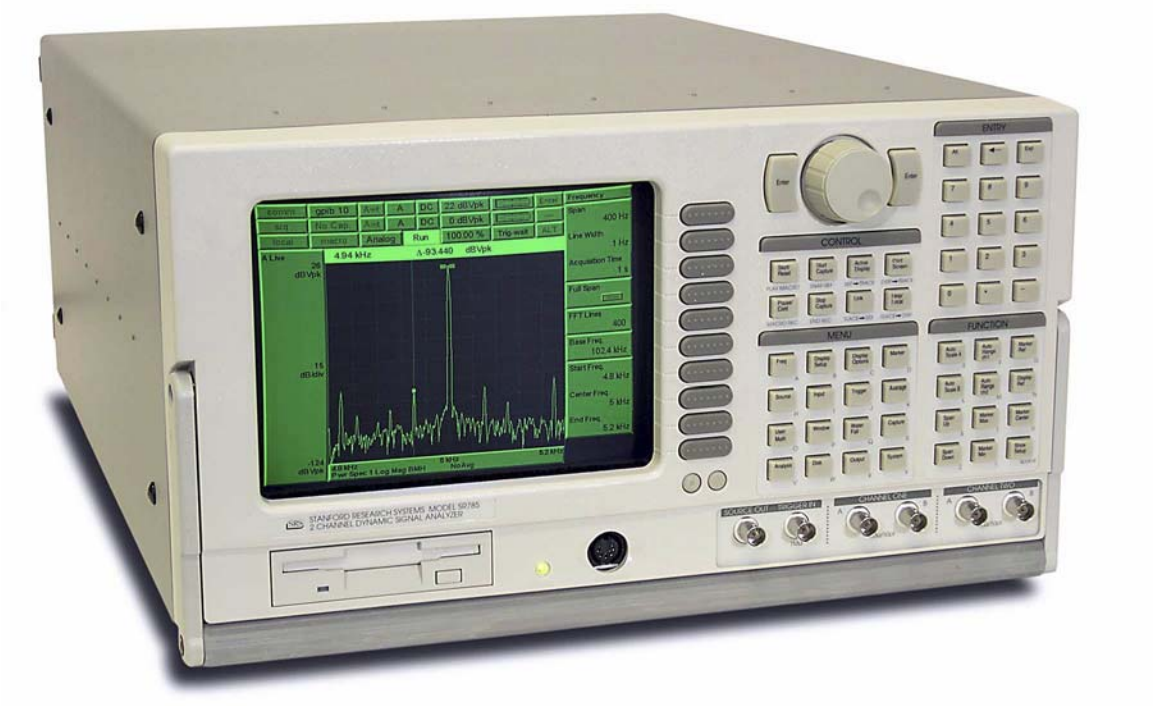

Figure 6:
Stanford Research Systems Model SR785 Dynamic Signal Analyzer

modes in the 8500 peak limiter.

Hard Clip Shape works only in HARD bass clip mode. It allows users to change the knee of the input/output gain curve of the bass clipper when BASS CLIP MODE is set to HARD. It allows users to control the shape of the "knee"—the transition between no clipping and flat-topping. "0" provides the hardest knee, where the transition between linear operation and flat-topping occurs abruptly as the clipper's input level is changed. "10" is the softest knee, where the transition starts 6 dB below BASSCLIPTHRESH setting and occurs gradually.

Bass Clip Threshold works only in HARD bass clip mode. It sets the flattop threshold of the bass clipper with respect to 100% modulation, which corresponds to 0 dB. If the HARD CLIP SHAPE control is set above 0, then the transition into clipping will start to occur at a level below the setting of the BASS CLIP THRESHOLD control.

Bass PreLimiting: When the BASS PRELIMIT MODE is set to MEDIUM or SOFT, the MX bass pre-limiter can intelligently reduce the bass applied to the main peak limiter to reduce or prevent audible IM distortion. It does so when the pre-limiter's analysis of the program material indicates that this action is needed to prevent or minimize audible IM distortion between the bass (125 Hz and below) and other program elements in the main peak limiter. The BASS PRELIMITING control allows users to specify the maximum amount of bass reduction that can occur. Lower settings increase bass punch but do not protect against IM distortion as effectively as higher settings do.

There are two controls, one for Speech mode and one for Music mode, allowing users to have separate settings depending on whether the 8600 automatically detects speech or music input.

Bass Limiting: Like the bass pre-limiter, the main peak limiter can automatically reduce bass when it detects potentially audible IM distortion. The BASS LIMITING control allows users to limit the amount of potential bass reduction at the expense of a possible increase in IM distortion.

Distortion Control: This control determines the amount of audible distortion that the main peak limiter is permitted to create. Higher settings can increase loudness and punch at the expense of audible clipping distortion. Lower settings are cleaner but may reduce punch and loudness. We prefer it at 0, which is its cleanest setting. All MX factory presets use this setting.

The best way to familiarize oneself with the effects of this control is by listening extensively to different types of program material within a user's station's format while experimenting with different settings of the control. Because the MX peak limiter uses newly developed algorithms that differ from those used by past Orban processors, the loudness/distortion/brightness/punch tradeoffs are also different and it is worthwhile to take the time to get a feel for the MX limiter's capabilities.

Conclusions

The marketing of broadcast audio processors has often suffered from objectively unverifiable hyperbole. Meanwhile, traditional measurements using static test signals like single-tone harmonic distortion and multi-tone IM distortion cannot rigorously predict the subjective listening qualities of broadcast processors because these processors are purposely very nonlinear, so that the assumptions implicit in test-tone measurements (that the systems being measured are ideally linear and that their nonlinearities are weak) do not hold.

This white paper has shown that with today's sophisticated digital measurement techniques, it is possible to verify some subjective claims objectively by making measurements that use real-world program material as the excitation. These measurements have verified that the 8600's new limiter technology has significantly improved high frequency power handling capability, distortion control, and transient punch compared to Orban's previous flagship FM processor.