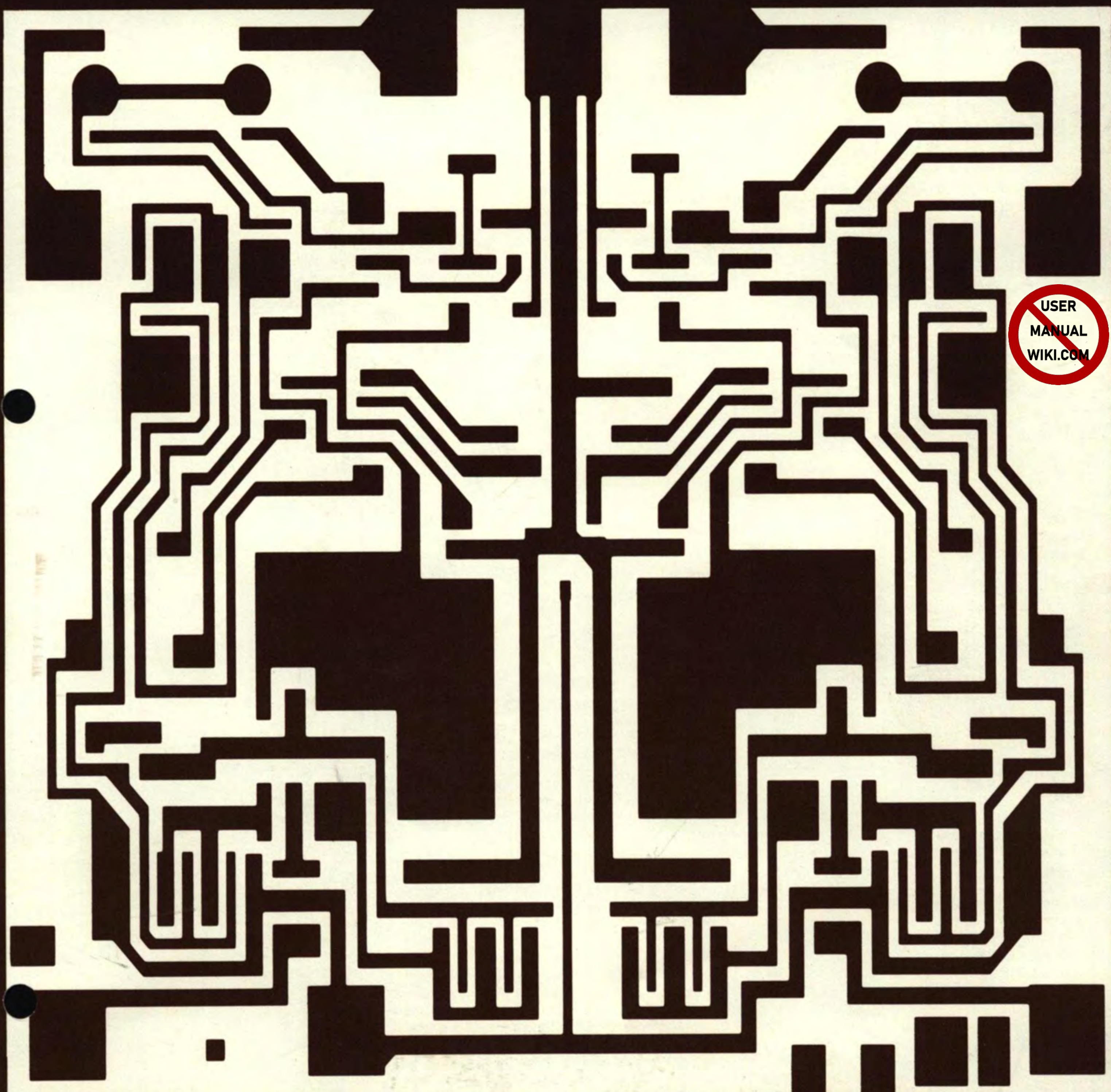
OPTIMOD-FM

The systems approach to optimum FM modulation



The most accurate fm limiter you have ever heard.

It would have made Major Armstrong very happy...

OPTIMOD-FM

Ever since the FM market became competitive, FM broadcasters have been searching for ways to increase the quality and punch of their signals. Many audio processing devices have been introduced which purport to accomplish this goal. Without exception, the loudness gains obtainable with these devices bring a concurrent loss in audio quality which is easily perceived even on receivers of moderate quality. Gritty clipping distortion, a dull high end, and an uneasy pumping quality were the price to be paid for loudness.

After six years of research, ORBAN/BROADCAST has finally discovered a dramatically effective solution to the loudness/quality dilemma. This new design by Bob Orban is now commercially available to broadcasters as the Orban/Broadcast OPTIMOD-FM.

OPTIMOD-FM is the result of a careful examination of every accepted principle of FM audio processing, and its effectiveness is due to a whole series of novel technical developments. The most revolutionary of these is OPTIMOD's system concept: the compressor, limiter, and stereo generator are engineered as a single system and incorporated in a single package.

The Gain-Control Revolution

Orban/Broadcast has thrown away conventional compressor/limiter design. Rather than diode attenuators with their high distortion, OPTIMOD utilizes clean FET attenuators. The FET's, combined with a highly developed delayed-release circuit, assures a total system harmonic distortion of typically less than 0.1% under any gain reduction condition.

Broadband Limiting

Broadband gain control is accomplished with a single AGC amplifier which utilizes a novel release-time computation circuit to perform both compression and limiting functions simultaneously. The release time characteristics match the psychoacoustical properties of the ear far more closely than do older designs. Time constants and other release characteristics have been fine-tuned through hundreds of hours of critical listening under acoustically calibrated studio monitor conditions. The result is simply stated: The OPTIMOD-FM broadband AGC is the most subtle most *musical* gain control ever offered to broadcasters. Eliminated are not only gross pumping, thumping, breathing, and other obvious misbehavior, but also the small gain shifts and musical miscalculations which cause the output of even the best of the older compressor/limiter combinations to sound audibly "processed." Yet OPTIMOD-FM is as loud or louder than these unmusical squashers and squeezers.

High-Frequency Limiting

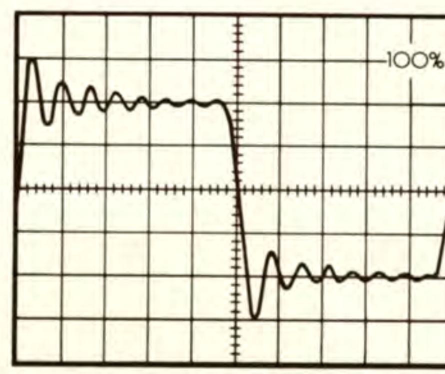
Because FM broadcasters must employ 75 microsecond pre-emphasis to match conventional receivers, overmodulation due to excessive high frequency energy must be avoided. Traditionally, such control results in either distortion or audible loss of high frequencies. OPTIMOD employs a newly designed high frequency limiter which results in no audible high frequency loss with at least 90% of modern recordings, yet is so clean that in introduces no audible distortion to even studio master tapes. Because of the attack and release time circuitry, high frequency loss (in the cases where it occurs) sounds perfectly natural—without the rapid pumping in and out of high frequency information characteristic of older designs—and can be detected only by direct comparison with the original program material.

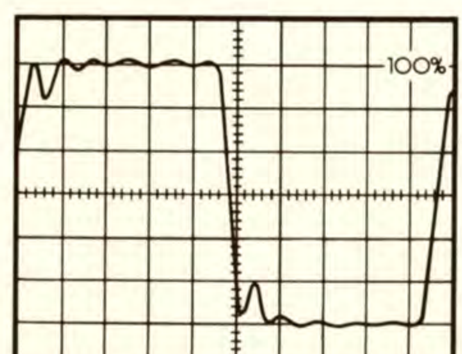
As a result of this rethinking of limiter/compressor design, OPTIMOD-FM is essentially transparent—*the output sounds exactly like the input*, and varies only in volume—as if a super-skilled human operator were operating a fader. The relatively large amounts of peak limiting which occur are so complementary to the characteristics of the ear that this limiting simply isn't heard. Yet, complemented by the OPTIMOD lowpass filter, it accomplishes its goal of achieving loudness which is audibly superior to conventional systems with most program material.

Control of Fast-Peak Overmodulation

Orban/Broadcast research has discovered that the principal cause of fast peak overmodulation—which has no effect on loudness, but which forces the broadcaster to lower his average level—is the lowpass filter incorporated in the input of every stereo generator of reputable manufacture. This lowpass filter is necessary to prevent interference between audio and the stereo pilot tone, and to avoid leakage between the main channel and stereo subchannel. Such filters are very sharp, and characteristically exhibit phase shift and ringing problems which introduce fast peaks as much as 30% to 40% above steady-state values—even if the limiter holds the peak levels at the input to the filter to precisely 100%. Because of the ringing and phase shift, the output level of the limiter must be lowered 2 to 3 dB in order to avoid illegal overmodulation on fast peaks.

Orban/Broadcast engineering has succeeded in designing a lowpass filter with the proper frequency response which overshoots a maximum of 3%, rather than the 30-40% of conventional filters. Therefore, peak modulation control in the OPTIMOD is "brickwall," without the sloppiness of conventional systems, and *average modulation levels can be raised 2 to 3 dB.* This gain in loudness is accomplished totally by eliminating sloppiness, rather than by further increases in compression and limiting. Thus, audio quality is not degraded. In addition, the tight peak control of OPTIMOD means no more insecurity over where to set modulation to avoid an FCC citation.





These scope photos compare the 1 kHz square wave response of the OPTIMOD lowpass filter with a conventional stereo generator's lowpass filter. Ringing in the conventional unit forces the steady state level down to 70% modulation to avoid overmodulation—a loudness loss of 3.1 dB compared to OPTIMOD.

Stereo Generator

The OPTIMOD stereo generator utilizes a Gilbert-linearized multiplier to generate the L-R subchannel directly. This subchannel is then summed with the left and right audio signals and with the 19 kHz pilot to form the composite stereo signal. As opposed to the conventional switching approach, this highly refined matrix approach offers superior separation across the audio band, as no composite lowpass filter is necessary. High frequency intermodulation distortion is outstandingly low. To assure proper 67 kHz SCA operation, spurious outputs in the SCA region have been held below −70 dB. The circuitry is so clean, quiet, and precise that distortion, noise, and separation are limited entirely by the performance of the preceding audio processing chain. Stability with time and temperature is assured by controlling pilot level, pilot phase, and L-R/L+R gain with feedback loops.

To secure reliability and compact size, extensive use is made of IC technology. Extraordinary effort has been expended in suppressing potential RF interference, assuring trouble-free installation.

Installation

The composite output of OPTIMOD has been designed to look like the output of a composite STL receiver. All major exciter manufacturers can supply interface devices for such receivers. In addition, Orban/Broadcast has successfully interfaced OPTIMOD to a number of popular exciters directly. We will gladly discuss your particular requirements with you personally.

To facilitiate installation directly into transmitter cabinets, a 230 volt connection is available on the power transformer.

Minimum required level for 10 dB gain reduction is −30 dBm, assuring satisfactory operation even if telephone line level is lower than normal.

OPTIMOD-FM has been designed to replace compressor, limiter and stereo generator. In the case of musical programming, *further audio processing will only degrade quality!*

Setup is outstandingly easy. A normal level mono signal is sent from the studio, and the *input level* controls are adjusted for desired gain reduction and L-R null, both of which may be read on OPTIMOD's integral meter. The *output attenuator,* a ten turn control, is adjusted for the desired modulation. *Pilot level* is adjusted using the station's modulation monitor, while *L-R gain* and *pilot phase* are adjusted using oscilloscope patterns in the conventional manner. All these controls are accessible from the front panel, and are protected by a screw-on security cover.

Operation

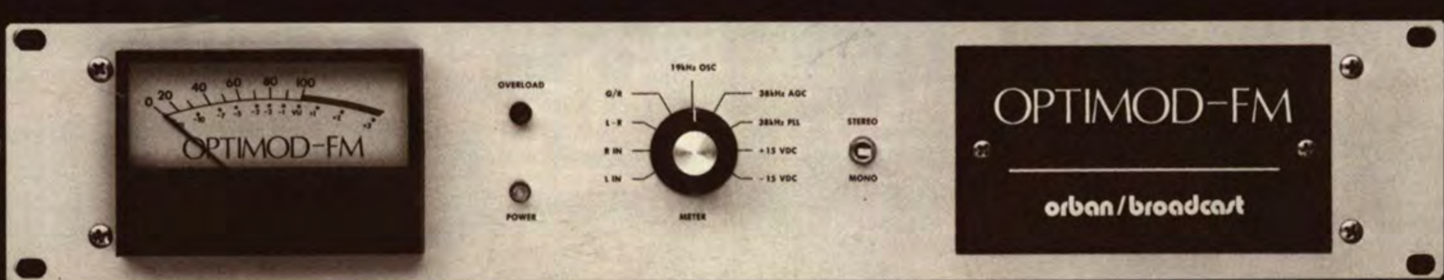
Broadband gain reduction has purposely been limited to 15 dB. This assures that excessive compression cannot be used. In addition, noise expansion is limited to a maximum of approximately 10 dB, which compares favorably to older compressors which are ostensibly gated to eliminate noise build-up, yet can pull up noisy low-level passages 15-20 dB before gating occurs. On-air experience to date indicates that a 15 dB gain reduction range is entirely adequate for normal operation.

Stereo/mono switching is accomplished with a front-panel momentary switch, and opto-isolated remote control of this function is available.

A Final Thought

OPTIMOD-FM is the ideal audio processing device for any format—hard rock to classical. The basic release time is user-controllable and may be adjusted for a specific format, but the range has been controlled so that objectionable results cannot be obtained. It stands to reason that there should be no such thing as a "rock limiter" or a "classical limiter"—both types of music are perceived by the same hearing mechanism and, if the limiter is well enough matched to the ear, then it will perform ideally with any type of music. Only if the limiter is not well-matched to the ear will different compromises be necessary for different formats.

OPTIMOD-FM has undergone extensive and rigorous development and testing in order to assure a long and reliable operational life without obsolescence. We sincerely hope that the availability of the OPTIMOD-FM will restore the audio quality of the FM medium to the true high fidelity status that was so much a part of Major Armstrong's original vision.



Specifications

Frequency Response (System in TEST mode)
Follows standard 75 μS pre-emphasis curve ± 1 dB, 50-15,000 Hz. 50 μS and 25 μS available on special order.

High Pass Filter
3rd order Chebychev with 30 Hz cutoff. Down 0.5 dB at 30 Hz; 10.5 dB at 20 Hz; 31.5 dB at 10 Hz. Protects against subsonic destabilization of some exciters' AFC's. Can be strapped out.

Noise
−74 dB max; −80 dB typical (50-15,000 Hz through 75 μS deemphasis).

Distortion, Total System
0.3% THD max, 50-15,000 Hz with any degree of gain reduction; 0.1% THD typical. In TEST mode (Instantaneous limiters & AGC defeated), below 0.05% typical.

Broadband Limiter Characteristics
Attack Time: Approx. 2 ms. for 10 dB gain reduction. Release Time: Program controlled by means of quadruple time-constant release time analog processor. Release time may be scaled fast or slow by means of continuously variable *Release Time* control available to user. Gain Reduction Range: At least 15 dB.

High Frequency Limiter Characteristics
Attack Time: Approx. 3 ms. Release Time: Varies around 15 ms. according to program material.

System Separation
Better than 40 dB, 50-15,000 Hz. Typically 50 dB or better overall.

Crosstalk
(Main Channel to Subchannel or Subchannel to Main Channel) Better than −40 dB, 50-15,000 Hz, as measured at input terminals of stereo generator per interpretation of Part 73.322 of FCC Rules. Crosstalk representing distortion components is typically better than −80 dB, as measured on a baseband spectrum analyzer.

38 kHz Subcarrier Suppression
−40 dB minimum, −55 dB typical.

Suppression of All Spurious Emissions in 67 kHz SCA Region
Better than −65 dB.

Modulation Control
System will overshoot no more than 3% with any program material whatever.

Pilot Frequency
19 kHz ± 2 Hz, 0-50° C.

Pilot Injection Adjustment Range
Less than 8% to greater than 10%.

Input
Impedance: 600 ohms balanced and floating, RF suppressed. Level: −10 dBm produces 10 dB gain reduction with *Input Attenuator* controls full CW. Removal of internal 20 dB pad permits −30 dBm to produce the same effect. Connector: Cinch-Jones 140-style barrier strip (#5 screw).

Composite Output
Impedance: 0-1250 ohms, dependent on setting of *Output Level* control; unbalanced. Level: 4 volts peak-to-peak max., continuously variable by means of 10-turn *Output Level* control available to user. Connector: Type BNC held floating over ground which permits interface to various exciters without use of wideband transformer and without creation of ground loops. RF suppressed. Cable: Max. length recommended: 24 " (61 cm).

Auxiliary Input/Output (for test use only)
Provides L and R lowpass filter output or L and R stereo generator input depending upon setting of rear apron NORMAL/TEST switch. Connectors are RCA Phono type, unbalanced. Stereo Generator requires approx. 3.0 V RMS for 100% modulation, unbalanced, with a source impedance of less than 50 ohms.

Operating Controls
Meter Selector; Stereo/Mono Mode.
Mode may be remote controlled by application of 6 to 24 V AC or DC pulses to appropriate rear terminals. Terminals are optically isolated, and may be floated ± 50 volts above ground. Three pairs of remote terminals will select either left or right audio inputs in *mono* mode, or *stereo.* Front panel switch may be strapped for either L or R mono.

Setup Controls (Front Panel, behind security cover)
Left and Right Input Attenuators; Release Time; Output Attenuator; Pilot Level; Pilot Phase; L-R Gain; Test/Operate Switch; Pilot On-Off Switch. Test/Operate Switch defeats all compression and instantaneous limiting in TEST position.

Indicators
Power On is indicated by green LED driven by unregulated negative DC supply. *Overload* is indicated by red LED which lights if operator attempts to exceed maximum achievable gain reduction. *Meter (VU scale and characteristics)* reads L and R input levels; L-R level; broadband gain reduction; 19 kHz oscillator level; 38 kHz gain control voltage; 38kHz phase control voltage; ±15 VDC regulated power supply busses. The gain reduction metering signal is available on the rear apron for remote application; +5 VDC corresponds to 0 dB gain reduction.

Power Requirement
115/230 VAC, ±15%, 50-60 Hz, approx. 12 watts. 3 prong, U-ground power cord attached. AC is RF suppressed.

Dimensions
19" (48.3 cm) wide x 3.5" (8.9 cm) high x 9.25" (23.5 cm) deep behind panel. Allow 2.5" (6.4 cm) additional depth for connections.

Weight
Approx. 13 lb. (5.9 kg) Net; 19 lb. (8.6 kg) packed.

Operating Temperature Range
0-50° C.

Warranty
One year, parts and labor. Subject to limitations set forth upon our standard warranty agreement.

All specifications subject to change without notice.

The ORBAN/BROADCAST OPTIMOD 8000A is recognized by the FCC for broadcast use when interfaced to a direct-FM exciter according to instructions provided by Orban Associates Inc. This may require purchase of a wideband interface from the exciter manufacturer.

orban/broadcast

orban

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ORBAN

BE tests the ORBAN OPTIMOD

By Dennis Ciapura

As any FM engineer who has labored to attain a satisfactory mating between signal processor and stereo generator knows, things are not always what they appear to be. Carefully adjusted systems often produce strange and unexplained peaks that tickle the peak flasher into luminous revolt and force the responsible engineer to lower the limiter output level to allow enough elbow room for these errant peaks.

It used to be common practice to blame the limiter for "letting a few peaks through" but these days most of us realize that the answer is not quite that simple, as there is another gremlin at work...the overshoot.

While some FM engineers have toyed with eliminating and/or repositioning filters and 75 μsec. networks in existing equipment to minimize the problem, it is one that does not lend itself to any easy solutions because of the number of variables involved. The Orban Optimod is a good example of a systems approach to optimum modulation control. In one compact unit, the Optimod is a complete signal processor and a stereo generator complete with low overshoot filters. Since the audio processing and stereo are designed as a system, the engineering folks at Orban are able to obtain the best balance between average level, fidelity and modulation control.

If you have been considering spilling the viscera of your limiter onto the shop table in an effort to duplicate the Orban scheme of things, don't bother. I doubt that you could duplicate the Optimod for what they sell it for, and as you'll see from our description of the circuitry, the limiter and stereo generator are specifically designed to complement each other.

Our investigation of the Optimod consisted of three phases. First, we obtained enough data from the manufacturer to get a clear picture of how the unit is supposed to work. Next, we ran our own lab tests to spot check the factory specs. Then, as a final test we used the Orban on the air under actual broadcast conditions.

How It Does What It Does

At this stage of the game, it would be helpful to take a look at the simplified block diagram of the Optimod in Figure 1. When we say simplified, we really mean simplified. As you can imagine, it takes quite a bit of electronic hardware to do what those little blocks call for.

Audio enters the unit at a rear panel terminal strip, and is then routed through a series of isolation pads and RF filters; an apropos welcome for audio that's been cohabitating with transmitters. The next section of circuitry provides a high-pass filter, active of course, that rolls off subaudible components below 30 Hz.

This filter was designed into the unit to accommodate exciters that can't handle low frequency transients. Although these high-pass filters would be very difficult to hear except with rare program passages, they are bypassable so that the purist can also be accommodated, assuming he has speakers that will reproduce wavelengths 16 to 20 feet long!

Next we come to the first of two audio processor sections, a broadband AGC. This section has a moderate attack speed and a variable recovery characteristic that is a function of the input waveform.

Ready for testing, the front panel was removed for access to the user adjustments.

Here you see inside. Note in the upper right corner that the input connections are shielded inside the unit.

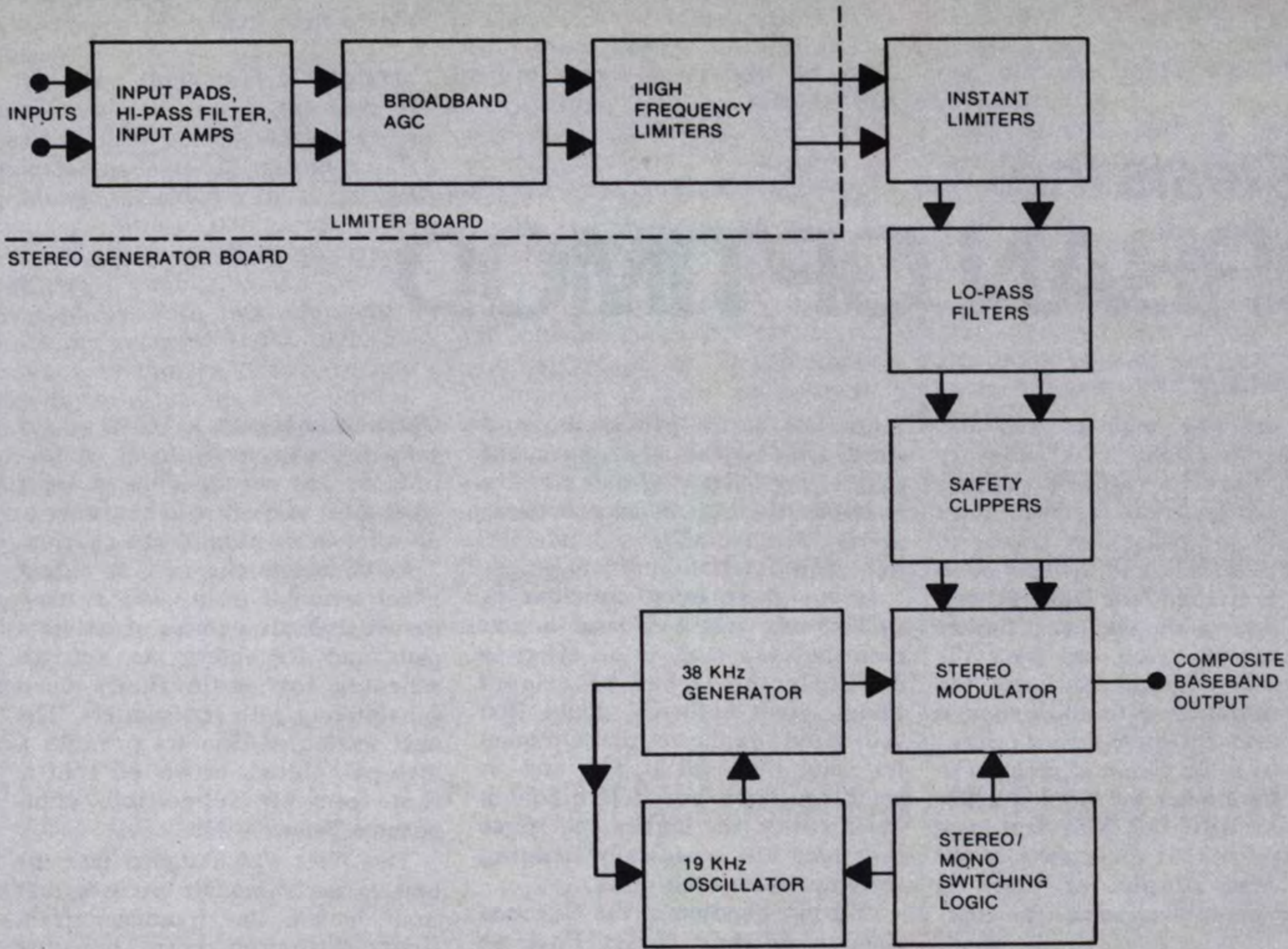

Figure 1. This is a simplified block diagram of the Optimod system.

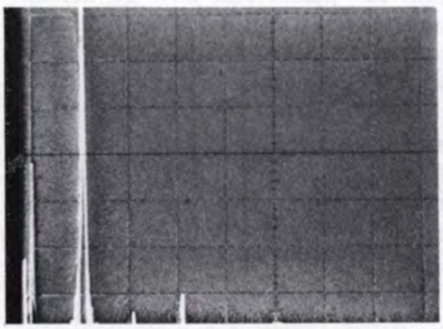

Figure 2. Harmonic distortion at 1 kHz without de-emphasis. Corrected for 75 μsec curve, 0.014%. (Scale is 10 dB and 1 kHz/div.)

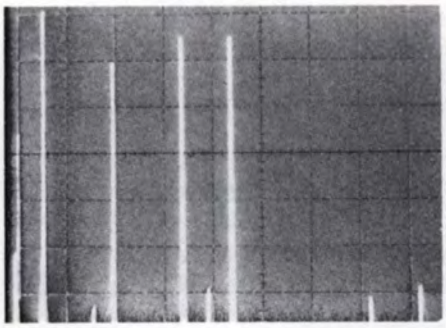

Figure 3. Composite output with 5 kHz left only audio input. Scale here is 10 dB and 10 kHz/div. 38 kHz is suppressed about 55 dB in this photo.

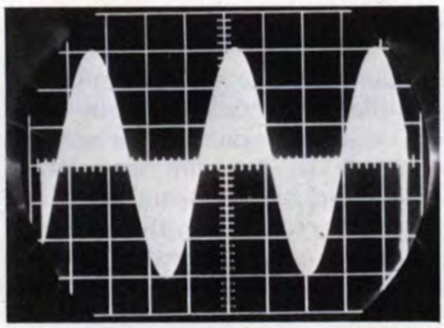

Figure 4. Composite output with left only input and 19 kHz pilot removed. Note the flat baseline. The unit was tested as shipped, and no adjustments were made. When this view was expanded, it showed better than 50 dB separation.

The Optimod's designers have determined that 10 dB of compression is optimum for broadcast, as any further squashing produces very little increase in average level. The Optimod's processing circuits, therefore, have been designed to provide the least audible control of the input signal up to 15 dB of compression. If this value is exceeded by much, an overload light signals possible audio degradation.

The AGC circuit itself is rather interesting as it employs an IC op amp whose input attenuation is controlled by an FET. The FET is operated at a relatively low audio level and is very well linearized for exceptionally low distortion. The output of the op amp is sampled by a comparator which drives the FET through a complex variable release time circuit, which is the key to its subtle inaudibility.

The high frequency limiters are similar to the broadband AGC, except that variable pre-emphasis is applied to the signal as levels and frequencies demand. The parameters of the high frequency limiters, like the broadband AGC, were based on hundreds of hours of listening tests to obtain the least audible action, and as we saw later in the listening tests (or should we say heard) the high frequency response is amazing considering the average level attained.

Out of the high frequency limiter the audio is passed through a temperature compensated instantaneous limiter using biased Schottky diodes in a shunt clipper circuit. Next come the active low-pass filters which protect the stereo pilot from supersonic audio components and prevent distortion causing "aliasing" which occurs when supersonic components fail to be properly encoded due to the relatively low stereo subcarrier frequency of 38 kHz: sort of like trying to modulate your 1000 kHz AM rig with a 1400 or 1500 kHz tone. The active filter circuitry utilized in the Optimod, however, is designed to provide the required protection with only two percent overshoot, which eliminates the erratic peak action that has plagued FM broadcasters for decades.

After final limiting by a safety clipper circuit to remove any slight overshoot that might occur, the audio is now fed into the stereo generator which uses a "Gilbert linearized" transductance multiplier.

In the final test data that accompanied the Optimod that we used for the tests, the factory noted that a Tektronix 5L4N Spectrum Analyzer had been used for the tests. Fortunately, we had the same instrument on hand, which gave us an excellent opportunity to duplicate the manufacturer's test set-up very closely. It would be a very interesting test indeed, as all of the factory's distortion figures were below 0.1 percent with midrange values down near 0.01 percent! The factory tests were made in the normal operating mode with 5 dB of gain reduction, conditions which we duplicated for our spot checks.

Our test results, which are recorded photographically in Figure 2, showed 0.014 percent harmonic distortion at 1 kHz when the ratio of the harmonics to the fundamental were corrected for standard 75 μsec. de-emphasis; exactly what the factory test sheet said and very close to the residual distortion of our signal source.

While we could have run our audio generator through a 1 kHz tuned circuit to remove its harmonic content, it seems a moot point when you're looking at figures in the 0.01 percent range. The output, by the way, was sampled at the composite output of the Optimod, so these figures are for the whole system, stereo generator included.

Figure 3 is a look at the composite output with a 5 kHz left channel input signal. Once again, correcting for de-emphasis, the audio harmonics can be seen down there well below 0.1 percent. 38 kHz suppression can be seen exceeding 50 dB, 76 kHz not visible at all and 76 kHz sidebands down about 70 dB. Frequency response was checked using the Low Frequency Spectrum Analyzer in conjunction with its tracking generator, and it was within a fraction of a dB from 50 to 15,000 Hz.

Stereo separation was found to be 56 dB at 400 Hz with the factory data showing 50 dB or less and 50 dB at 15 kHz, which equaled the factory data exactly. Figure 4 shows the composite output with the pilot off. Note the flat baseline. The factory said that the pilot frequency was -.48 Hz from the ideal 19,000 and we measured -.50 with our counter.

All in all, the Optimod really did live up to its specs. We were anxious to get into the operational part of our review and find out what the unit could do with a program input and what it sounded like on the air connected to a typical transmission system.

For the actual operational checks we were interested in several factors. First of all, how is it built? The unit is a very high density package. It's easy to service, though, because of the way it's laid out. What you can't see from the photo is the quality of components. Many parts are military grade and important adjustments like the composite output control are multi-turn pots. The inputs are very well shielded and filtered against RF.

The front panel meter can be switched to monitor just about anything you might want to monitor, including audio input levels and gain reduction. At proof time the test switch defeats all limiters and controls and provides up to 10 dB of headroom so that a proof can be accomplished without re-adjusting the output levels. A front panel release time control provides the user with some degree of control over the control characteristics but not so much range that you could really make it sound bad.

If the input levels are adjusted so that the meter reads normal deflection to full scale with a program input, an average of about 8 to 10 dB of gain reduction will be taking place, a value that the Orban people have found to produce an optimum balance between dynamic range and average modulation level.

The user is free to tailor his own sound, however, by experimenting with different combinations of input levels and release times. An engineer interested in full dynamics and the ultimate in fidelity could operate the unit with lower input levels and the slowest release time. On the other hand, an engineer interested in a really high average modulation level at all times would choose normal meter deflection when monitoring the input and a faster recovery time, thus increasing the density of the audio signal.

The Optimod was mated with a Harris FM20 H3 transmitter, chosen because it currently is in wide use and therefore representative of the type of equipment that you're likely to operate the Optimod with. With many rigs, no interface is required, but the TE-3 exciter in the Harris requires a matching unit that is normally used for hooking a composite STL to the modulated oscillator input. The whole installation only takes a few minutes and once on the air, the pilot and composite output level adjustments are a statement of the obvious.

The first thing that is likely to impress a new user is the lack of peak flasher activity for a given modulation level. If the output is gradually increased until the peaks are just hitting 100 percent, the average level is at 80 to 90 percent and yes, Virginia, there are no overshoots. The next departure from the expected is the high frequency response. Orban recommends not using any other processing gear ahead of the Optimod and so do we. The unit does a fine job all by itself, and any additional devices would only detract from the clean reproduction that it yields.

Even when operated with the input levels 7 or 8 dB below normal so that almost no gain reduction is produced in the broadband AGC, the clever design of the high frequency limiters allowed an unusually high average level with extremely good fidelity. The input source levels do, of course, have to be rather well-controlled when operating in this mode, but that is usually not too difficult with automated tape systems. Most stations would probably want to use the unit with normal input settings to take advantage of its automatic leveling and to gain an optimum average modulation level.

Next, an H.P. 8558 High Frequency Spectrum Analyzer was set up to measure the occupied bandwidth. Our test unit was fed easy listening program material, which is not notorious for causing modulation problems. We also checked a rock station in town that has an Optimod and in both cases we found the sides to be well within FCC limits.

The Optimod comes to its new home with a very comprehensive instruction manual and lots of explanation about how it works for the guy who wants to plan his own customized adjustments. At the same time it's simple enough to install and set up so that less adventurous persons can be assured of a good sound with a minimum of tweeking.

The stereo generator itself would probably be worth the price to many stations who have older units that just barely make minimum specs, or worse. For those stations, the processing features are a nice bonus. □