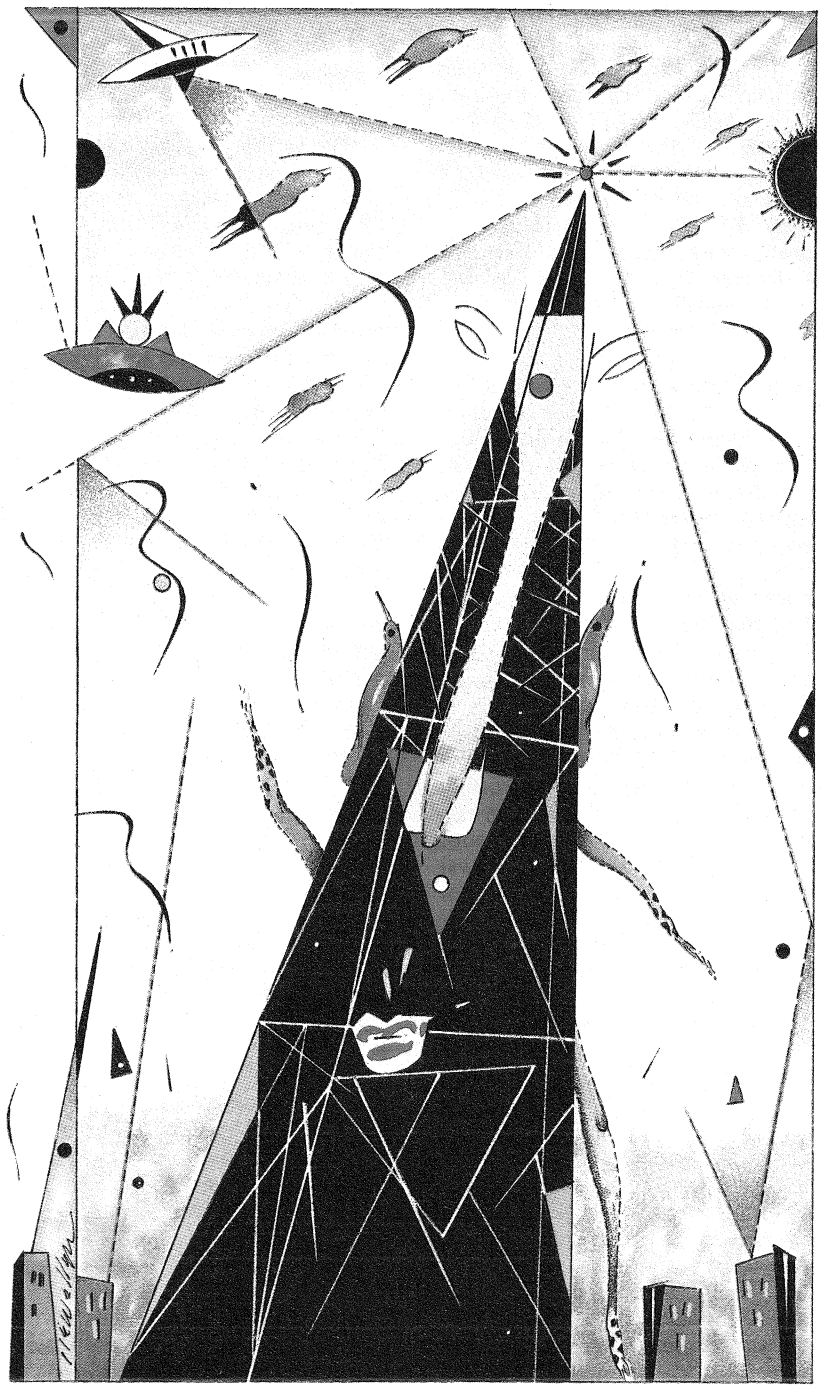
THE NOISE ABOUT FMX

Controversy surrounds what seemed to be a promising technique for improving stereo FM reception.

BY RICH WARREN



SUE LLEWELLYN

BACK in the Forties, FM came to market as a panacea for the noise that plagued AM radio transmissions. The wide bandwidth of FM channels and the technique of frequency modulation itself were both intended to insure low-noise reception. Now, ironically, it is noise in FM signals that is at the heart of a controversy in audio circles over a technique called FMX that was developed to improve FM broadcasts.

In the beginning, FM was a very quiet medium, but the change to stereo complicated matters, increasing noise (especially on weak signals) and susceptibility to multipath distortion. Multipath, just as the name implies, occurs when a radio signal reaches a receiver along different routes. Radio waves all travel at the speed of light, but some reach your receiver directly while others bounce off buildings and mountains, reaching your receiver out of phase some fractions of a second later.

Multipath caused few problems for the original mono FM transmissions, but few people listened, and the FM broadcasters could barely support themselves. So the government permitted them to add SCA (Subsidiary Communications Authorization) subchannels for specialized programs, such as Muzak or stock quotations, for commercial customers with special receivers. By itself, an SCA causes only modest

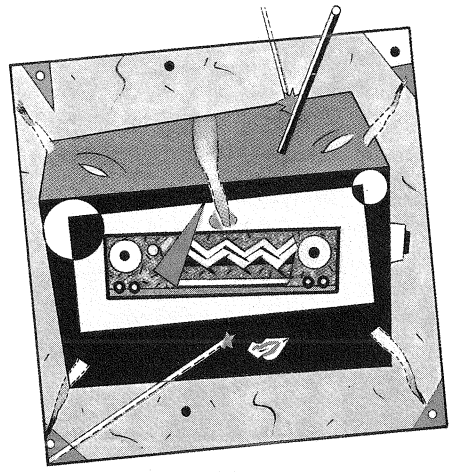
reception problems, but then came stereo FM, which requires an additional subchannel. When SCA's are combined with stereo transmission, the signal degradation from multipath can be severe, ranging from occasional whistles and "birdies" to unlistenable distortion.

Stereo FM begs for improvement, and various visionaries have risen to the challenge. In the early Seventies, Ray Dolby designed a modified version of his consumer noise-reduction system for FM. Dolby FM arrived with a great flourish but shortly faded. The Dolby system required changing the FM pre-emphasis time constant, which caused non-Dolby-equipped listeners to endure a brighter sound. Custom-application integrated circuits were uncommon fifteen years ago, which meant that equipping receivers for Dolby FM was expensive. Ultimately, consumers and broadcasters decided that the improvement was not significant enough for the required investment.

ABOUT a decade after Dolby's foray into FM, Emil Torick, an engineer at the CBS Technology Center (formerly known as CBS Laboratories), took up the quest for improved stereo FM. Torick and his associates seemed to discover a way of improving the stereo FM signal without negative side effects. They called their system FMX.

In effect, FMX employs techniques similar to a conventional tape-recording noise-reduction system: boosting the low-level signals, applying equalization during transmission (recording), and decoding the result with a complementary circuit on the receiving (playback) end. Unlike a tape noise-reduction system, however, FMX uses a control signal to insure accurate decoding. The existing stereo difference subchannel becomes a control for the compressed, equalized subchannel. (See box on page 115 for details.)

The idea is that listeners with non-FMX-equipped radios will hear minimal difference from an FMX-encoded broadcast, while those with FMX-equipped radios will benefit from reduced noise. Reducing noise should also increase the usable range of the stereo signal. If you live 60 miles from the transmitter and have been forced to listen in mono because of a noisy signal, FMX might enable you to listen in stereo.



The first time out of the gate FMX stumbled. After considerable fanfare at the 1986 Winter Consumer Electronics Show, FMX made a major debut during the Summer CES later that year. The CBS Technology Center loaned classical-music radio station WFMT in Chicago a prototype FMX exciter. The station was ideal for the test because of its renowned signal quality. Without public announcement, WFMT began broadcasting with FMX. During the first week WFMT received a significant number of telephone calls from listeners complaining about poor reception. WFMT's engineers tied the listener complaints to exaggerated multipath distortion caused by FMX, and the station swiftly ended the experiment.

Undaunted, Torick and associates returned to the lab. Although CBS closed the Technology Center in 1987, the FMX project continued. The National Association of Broadcasters (NAB) subsequently became an investor in FMX, and Broadcast Technology Partners (BTP) was formed.

In the spring of 1988, BTP premiered the newly revised FMX system at the NAB convention. The new FMX reduced the compression curve (from 20 to 14 dB), altered the equalization, and inverted the phase of the FMX signal. Assuring broadcasters that all problems had been solved, BTP began to campaign for adoption of FMX by the world's FM broadcasters.

Meanwhile, FMX sounded like an interesting idea to Dr. Amar Bose, founder and chief executive of the Bose Corporation and a full professor at MIT. Bose began his academic career in communications theory, and he loves mathematics. He obtained the specifications for the revised FMX system and began investigating them.

After mathematically analyzing the relationship between FM broadcasting and FMX, Bose reached the conclusion that FMX could not work as claimed. His calculations predicted that FMX could grossly degrade a stereo FM signal. The problem centered around multipath. Multipath changes the relationship between the normal stereo subcarrier and the FMX subcarrier. Thus, FMX loses its "control" signal, since the two subcarriers are in a different relationship when they're received than when they left the transmitter. In addition, Bose noted, the extra subcarrier increases "channel loading," which theoretically increases noise.

Research facilities at MIT aided Bose's investigation. He was joined by Dr. William Short of the Bose research staff, who conducted many of the experiments. First they created a computer model of the problem. Then they set up a laboratory experiment to simulate the effects of multipath. Basically, a signal was sent down two wires of different lengths, one very short and the other 2,000 feet long. One signal reached the receiver later than the other, just as with FM multipath. The laboratory findings confirmed the mathematics.

FOR the final step Short conducted actual off-the-air experiments. He obtained a current Inovonics FMX exciter for use by the MIT student radio station, WMBR. A car radio was modified to receive FMX with the latest Sanyo integrated circuit, and it tuned in a special test signal while the car was driven over a wide coverage area. The stereo outputs of the radio were digitally recorded for subsequent computer analysis in the laboratory. Both the transmitter and the radio were switched between conventional FM stereo, FMX transmission with conventional reception, and FMX transmission with FMX reception. The broadcast test also confirmed Bose's predictions.

Bose went public with his findings in a press conference at MIT last January. He was joined by Short, who presented the experimental portion of the project. In their initial publication of the results, which bears an MIT copyright, Bose and Short state: "We have examined

two systems of FM transmission that are of current interest—the existing FM stereo system and the proposed FMX system. The results of modeling, simulation, and objective field testing at 15,000 locations lead us inescapably to the following opinions: 1) Broadcast station coverage, instead of being increased as originally hoped, is decreased by the FMX system; 2) FMX transmission degrades reception on existing FM stereo receivers; 3) FMX receivers are inferior to existing FM stereo receivers for receiving FMX transmissions." During the presentation Short played recordings of the various off-the-air tests. The FMX broadcasts, both with and without FMX decoding, contained nearly unlistenable amounts of distortion.

SHORTLY after the MIT presentation, BTP responded with a nine-page rebuttal. The BTP analysis disputes Bose on the following salient points: 1) The transmission equipment used for the Bose–Short broadcast tests was not properly adjusted. BTP claims that it offered to adjust WMBR's equipment but was refused (Bose denies this claim). BTP says that WMBR suffered synchronous amplitude modulation, a form of distortion that is often mistaken for multipath. 2) The modification of the car radio used in off-the-air compatibility tests resulted in misleading stereo/FMX comparisons. 3) The experimental radio used by Bose incorporated an unapproved prototype sample of the Sanyo FMX decoder chip. 4) The laboratory simulation was unrepresentative of real-world conditions. 5) There is only an extremely low probability that the kind of reception simulated by Bose and Short would occur in real life. 6) Bose's mathematical presentation does not describe parameters of the FMX system that differentiate it from regular stereo FM.

Regardless of the merit of BTP's arguments, FMX does lack compatibility with some FM receivers—certain receivers cannot properly process a signal with the kind of subcarrier FMX uses (see box). Therefore, the FMX system cannot support a claim of "universal" compatibility.

Broadcast engineers who have seen the Bose report tend to agree with Bose. While BTP's rebuttal lists stations using FMX, many of them have ceased using the system. For instance, WNIB, another classical-music station in Chicago, broadcast with FMX last year but ceased doing so two months before the Bose/MIT press conference. WNIB staff member Ron Rai said that the station suffered too much distortion when broadcasting with FMX. An engineer at another Chicago radio station, however, suggested that the McIntosh tuner used by WNIB to receive its broadcast signal from the station's downtown transmitter, for relay to its repeater transmitter in Zion, Illinois, could not receive the FMX broadcast properly.

WBBM-FM, a CBS-owned rock station in Chicago, broadcast with FMX during the 1988 Summer Consumer Electronics Show but ceased using the system shortly thereafter. An engineering representative at the station referred questions to CBS corporate headquarters in New York. Helene Blieberg, a CBS representative in New York, said that WBBM-FM engineers "noticed interaction between FMX and subcarriers which resulted in noise on inexpensive radios." She estimated that these radios constituted about 10 percent of those used by the station's listeners and added that CBS had discontinued FMX broadcasts until the engineering staff could correct the problem. As of July 1989, WBBM-FM had not returned to FMX broadcasting.

SANYO and Sprague are the only manufacturers of FMX integrated circuits. The only two audio companies actually marketing mobile FMX receivers are Alpine and JVC. The attitude of the rest of the industry varies from a cautious "wait and see" to a lack of interest. Aware of the financial beating suffered by NAD when it announced the first FMX receiver for the original FMX system three years ago, few companies are eager to invest in FMX. Tom Harvey, president of Sony's consumer products division, wants to see FMX operating "flawlessly" before considering it.

As far as the audio industry is concerned, the jury is still out on FMX. Home audio manufacturers apparently aren't willing to bank on FMX until its designers have shown that it works and is compatible with existing receivers. But, considering the severity of the problems associated with stereo FM reception, everyone concerned hopes that *some* solution is on the way. □

WHAT FMX DOES

JUST as today's FCC (Federal Communications Commission) has ruled that the competing high-definition television (HDTV) systems must either be compatible with our existing TV system or else their broadcasts must be simulcast with conventional TV signals, thirty years ago the FCC mandated that stereo FM transmissions be compatible with existing mono broadcasts. Furthermore, the FCC sought a system for stereo FM that would not penalize mono listeners in terms of reception quality.

The Zenith stereo FM system that was eventually accepted, and is still used today, barely affected mono reception, but it placed an 18-dB penalty in signal-to-noise ratio on stereo transmissions. The system adds an amplitude-modulated stereo difference-signal (L − R) subchannel at 38 kHz to FM broadcasts, and a subcarrier is added at 19 kHz to help decode the stereo signal (this 19-kHz "pilot" signal is what triggers the "stereo" light on your receiver).

FMX was designed to improve the signal-to-noise ratio of stereo FM in a way that is compatible with the existing system. In operation, the FMX system boosts low-level program signals by 14 dB. As program levels increase, the amount of boost is gradually reduced in order to permit transmission at full modulation to receivers without FMX decoders. FMX then applies fixed equalization to a compressed duplicate of the existing stereo difference signal; complementary equalization in an FMX receiver is used to provide optimum noise reduction.

The compressed FMX stereo difference signal is transmitted on a new "quadrature" subcarrier, which is 90 degrees out of phase with the existing 38-kHz stereo FM subcarrier (which transmits the original, uncompressed difference signal). In an FMX-equipped receiver, the conventional stereo subcarrier is used as a reference for decoding the FMX subcarrier. Finally, the system adds a new pilot signal at 10 Hz, well below the audible range, that switches an FMX-equipped receiver into FMX mode.