A LOOK AT AM STEREO

By Greg Monti

On September 24, 1975, the National AM Stereophonic Radio Committee was formed to look into ways of broadcasting two-channel audio on a single AM radio station. The NAMSRC was set up by the Electronic Industries Association, National Association of Broadcasters, National Radio Broadcasters Association, and the Institute of Electrical and Electronics Engineers. In time, the committee tested three possible ways of squeezing stereo out of an AM transmitter, those proposed by Magnavox, Motorola and Belar. Two other systems, proposed by Harris and Kahn/Hazeltine, were not tested by the committee, Harris' because it arrived too late, and Kahn's because that company felt it was too small to afford additional tests of its system. (The Kahn system had already been tested at XETRA-690 several years back.) The committee's report went to the Federal Communications Commission on December 19, 1977. Many proponents of AM stereo are now saying that the FCC is dragging its feet on this matter because the commission has yet to approve one system for national use. The deadline for reply comments was August 3, 1979. Rumor now has it that the FCC will announce its chosen system this spring. Undoubtedly, it will have enormous repercussions in both the broadcasting and consumer hi-fi equipment businesses. What are the five competing systems and what are their advantages and disadvantages? Without getting too technical, let's have a look.

There are two basic problems with AM stereo: bandwidth and tradeoffs. AM stations, under current rules, are not supposed to occupy more than 30 kHz of overall bandspace during normal program transmission. (This is contrary to the popular belief that AM stations are only supposed to occupy 10 kHz.) FM stereo stations occupy a good 150 kHz or more. This makes it easy to transmit stereo, since the information needed to separate the left and right channels can simply be encoded on a subcarrier, a "tone" too high in frequency to be heard by humans, which is mixed in with the program audio. The challenge in AM stereo is to get everything to fit into the allocated 30 kHz of bandwidth. Basically, all five AM stereo systems encode the information needed to separate the left and right channels by altering the frequency or phase of the AM station's carrier wave by a small amount. Thus, all the systems are substantially AM-FM systems, where amplitude modulation is used to carry the mono information and frequency modulation is used to carry the stereo information.

This is where tradeoffs come in. An ordinary, mono AM receiver does not respond well when receiving a frequency-modulated wave. Often, the receiver will exhibit gross distortion of the audio, making the programming unlistenable. Each inventor of an AM stereo system claims to have come up with a way to minimize this distortion, either by only FMing the carrier by a small amount, or by pre-distorting the audio program in such a way that it comes out sounding okay in the end. Not only must the program sound reasonably undistorted on old, mono receivers, it must sound reasonable on the new stereo receivers that will eventually be marketed. If pre-distortion is used to make up for one type of receiver, it may make another sound worse.

In making their decision on which stereo system should become standard the FCC must consider 1) the above distortion and bandwidth problems and requirements, 2) how the system will perform under fading or skywave reception conditions, 3) how it will sound on a mistuned receiver, 4) how much noise, if any, will be heard at receivers, 5) whether the service areas of existing AM stations will be reduced by implementing stereo, 6) how much stereo separation the systems offer, 7) what kind of frequency response can be expected of both transmitters and receivers, 8) how expensive receivers will be to design and build, and 9) whether the system provides for a stereo indicator lamp on receivers and how quickly that lamp will light when a listener tunes to a stereo station. Each inventor of an AM stereo system places different importance on each of the nine factors listed above and is trying to convince the FCC that their list of priorities is the best one. The FCC's problem is compounded because there exists no one, unbiased source of technical specifications and test results which the commission can use to compare the five systems.

Even though all the systems are basically AM-FM types, each inventor uses a different mathematical function as the basis of how his system works. Belar (a manufacturer of radio station test equipment like modulation and frequency monitors) uses straight AM-FM. Belar propses shifting the station's carrier frequency by no more than 1.25 kHz to carry the encoded stereo information. Magnavox (a manufacturer of home entertainment equipment) uses the term "phase modulation", which is analogous to FM, to describe their system. They propose that the carrier not be shifted in phase by more than 57 degrees as it carries the stereo information. Harris (a major transmitter manufacturer) and Motorola (largely a television receiver and car radio maker) both propose forms of what is known as "quadrature modulation" to carry the stereo. Quadrature modulation could be produced by having two transmitters operating on the same frequency, but with their carrier waves 90 degrees out of step ("in quadrature"), each carrying one of the two left and right channels. In practical applications one transmitter would be used, and complex mathematical functions could be applied to the carrier wave to make it behave like quadrature modulation. The difference between Harris and Motorola is the way they keep down the distortion. Harris does it by having the two carriers only 30 degrees apart instead of 90. Motorola does it by pre-distorting the audio just enough so that (they claim) it sounds reasonable on both stereo and mono receivers. The Kahn/Hazeltine system is called "Independent Sideband". Ham radio operators or shortwave listeners who are familiar with single-sideband operation will understand that the Kahn system is equivalent to having two transmitters on the same frequency, each operating in single-sideband mode and each carrying separate audio channels. Obviously, one transmitter would have to operate lower-sideband, and the other upper-sideband. Once again, in practical applications, only one transmitter would actually be used, with complex mathematical operations performed on its waveform so that it would appear to be independent-sideband.

Each manufacturer has proposed a way to indicate stereo reception on receivers. Harris proposes sending out a low-frequency tone of about 20 or 25 Hz in the stereo information ("left-minus-right") channel. Kahn proposes using a 15 Hz tone. Magnavox proposes a 5 Hz tone, and Motorola propses a 25 Hz tone. Belar's original proposal did not contain any proposal for a "pilot tone", but it says it has invented a system of detecting whether a broadcast is stereo or mono without one. Makers of auto radios say they want the stereo pilot light to turn on within 1/10 of a second of the tuning-in of an AM stereo station. They say that their experience with FM stereo car radios tells them that listeners will want to see a "stereo" light that quickly while "dial-cruising".

How will AM stereo's implementation effect the broadcasting and consumer electronics industries? For one thing, many mono radio stations will have to purchase a lot of new equipment. Some estimate that re-equipping an on-air studio will run $20,000 and re-equipping a transmitter will run $3,000 to $5,000. Listeners should also be expecting better received audio quality once the new AM stereo receivers flood the market. Most people have just been assuming all these years that AM sounds muddy, boxy, or tinny, when in fact, AM stations are capable of audio quality rivaling that of FM. In the past few years, many AM broadcasters have taken to heavily processing their program audio before sending it to the transmitter in an attempt to overcome the serious deficiencies in modern, mono AM receivers. Listeners should look for audio bandwidth out to about 10 kHz instead of the typical receiver high end of 2 or 3 kHz prevalent today. Manufacturers of home and car receivers are all anxiously awaiting the FCC announcement. All of them have designed printed circuitry or integrated circuit chips which are capable of decoding AM stereo for all five of the competing systems at no little expense. Four of the designs will necessarily have to be thrown away when the FCC's decision comes through.

Even though the FCC's comment and reply deadlines have long since passed, the competing manufacturers are continuing to file comments with the commission. Recently, Harris submitted a last-minute filing saying that the Motorola and Kahn systems exhibit excessive distortion, while theirs is more compatible. Motorola promptly filed, criticizing the Harris system. Harris also claimed compatibility with any 9 kHz station separation scheme and said its system had better stereo separation than Kahn's. Kahn then said that its tests at WABC-770 showed it to be equivalent to FM quality. For sure, there have been more last-minute filings, each asking the commission to close the casebook after entering the last-minute file. Each manufactuer wants to have the last word because the winner will have exclusive rights to its own system and all the manufacturers will have to pay patent license fees to the owner of the only government-approved system.

For those who wish a try at second-guessing the FCC, herewith is a table listing the advantages and disadvantages of each system (or as many of them as I could come up with).

Manufacturer (principle)	Advantages	Disadvantages
Belar (AM-FM)	**Truly compatible with mono receivers. **Transmission and reception are straightforward.	**Second-worst in occupied bandwidth. Splatter exceeds current specs. **Possibility of noise bursts if 100% negative peak modulation is used and the carrier disappears momentarily.
Harris (Modified quadrature)	**The only proposed linear system. **The best mono distortion figure. **Does not require amplitude- or phase-coherent front ends in receivers. **Occupies the narrowest bandwidth of all, fits current FCC splatter specs. **Typically 30 db separation.	**Stereo may be a bit noisy.
Kahn (ISB)	**Can be received in stereo on two mono receivers, each tuned to a different sideband **Claimed to be indifferent to fading, skywave, or phase-shifting. **Second-best in mono distortion.	**Complex system for both transmission and reception may be expensive. (Requires fixed-angle phase shifters.) **Second-best in occupied bandwidth, but does not meet current FCC splatter specs.
Magnavox (AM-PM)	**Straightforward transmission and reception.	**The worst system for mono distortion. **Possible noise bursts if 100% negative peak modulation is allowed. **Splatter out of spec.
Motorola (Compatible quadrature)	**	**Heavy burden of critical phase and level requirements is placed on receiver to cancel distortion. **Second-worst in mono distortion. **Worst system for occupied bandwidth. Exceeds FCC splatter specs.

Sources:
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Mennie, Don; "AM Stereo: Five Competing Options", IEEE Spectrum, June 1978.

Thanks to Bruce Portzer for forwarding the above articles to me.