Interference & Envelope Detection

Interference, because of the quadrature distortion effect, produces a non-linear multiplicative product that is not present in the sidebands. For an envelope detector to produce no distortion there must not be any signal in the quadrature channel otherwise the envelope output will be $\sqrt{I^2 + Q^2}$ (Letting $I = 1 + L + R$ & $Q = L - R$), the squaring and rooting of the 2 signals, the non-linear function, produces distortion. As for interference it is non-coherent in relation to the carrier and exists in both the I & Q channels producing said distortion.

This is true for a Stereo QuAM signal when envelope detected producing mostly the even 2nd 4th, 6th, etc... harmonics. For regular program material, for the vast majority of cases, it appears to the listener as an increased treble boost, something badly needed for todays bandwidth restricted radios, kind of a natural spectral band replication that sounds better than most SBR of competing digital encodings.

For envelope compatibility Motorola took the phase modulation of the QuAM signal and modulated it with $1 + L + R$. Since the envelope of the QuAM signal has $1 + L + R$ as a component along with $L-R$ then re-modulating the envelope with $1 + L + R$ produces less of a brute force approach than some of the other systems and is a logical and more natural approach. The downside is that forcing an Armstrong phased modulated signal to carry an envelope other than its own makes it non-linear and places a more stringent requirement of phase linear reception on receivers for good stereo decoding.

Now this is not real world conditions, in fact it is just the opposite especially for the older mono radios where a non-linear stereo signal, supposedly envelope compatible, will produce some distortion with an envelope detector. All of the non-linear systems, from worst to best compatibility: Magnavox AM/PM, Motorola C-QuAM, Belar AM/FM, & Kahn ISB, produced some distortion when the TX/RX path does not have a flat group delay (GDT) response in the passband and sideband amplitude symmetry. Only the linear system, Harris with the variable quadrature angle QuAM limited to ±15° phase deviation, produced considerably less envelope detector distortion out of all of them.

In C-QuAM since the envelope is the reference for proper stereo decoding and both phase and amplitude are part of the distortion correction process there is a relationship to the tangent function regarding $L-R$ where: $L-R = Env \times \tan\theta$ and $Env = 1 + L + R$. Now most who have studied trigonometry know that $\tan(90°) = \infty$ and given that during maximum single channel modulation of a stereo signal during negative peak modulation the phase is almost at 72°. It doesn't take much of a noise interference component to push it towards 90° and then "pop goes the weasel" so to speak ;-). This occurs when the S/N ratio of the received signal drops below ~21dB making C-QuAM the least desireable system to use in the SW bands and is best suited for the local MW/LW bands only. I do want to point out that Motorola with the 3rd generation chips like the MC13028 has done a great deal of work to overcome some of the limitations of a received C-QuAM signal during noisy conditions. Of all the non- linear systems KahnISB is the most desireable and Magnavox and Belar somewhere in the middle.

For Motorola C-QuAM with the 1st generation decoder chips they preformed very well on strong local daytime signals but showed their limitations during nighttime skywave interference and distant skywave reception was mostly out of the question. Now with the 3rd generation decoder chips like the MC13028 reception has greatly improved even for skywave reception but there are limitations for envelope detection of skywave signals. When signal quality is this poor better sound is produced when even a C-QuAM signal is synchronously detected as a QuAM signal. The distortion of synchronously detected reception of the non-corrected per-distorted sidebands of a C-QuAM signal are nothing compared to the envelope detector distortion during heavy interference conditions.

The FCC required the systems submitted for approval to be completely envelope compatible and since the L─R portion had to be encoded into the angular modulation of the signal in some shape or form via FM or PM and the envelope had to be 1 + L + R this meant that the adopted system had to be essentally mathematically non-linear. If the full TX/RX path was completely phase linear, a flat GDT, and upper and lower sidebands had perfect amplitude symmetry then at the envelope detector 1 + L + R would be detected completely distortion free. However this is not a real world condition but C-QuAM could be made to work reasonably well but placed tighter restrictions on the transmitter hardware and calibration more so than some of the other competing systems.

Now I'm not going to go into why the best overall system was not chosen be it one of the submitted systems or a cherry picking the best features out of the 5 submitted, let's just say that he who has the most bucks wins. Not much different than what we have now with the HD Radio money grab whereas at least DRM is open source. You see even DRM being royalty free hasn't met with a great deal of success either. This type of market manipulation is what sabotaged the quick adoption and implementation of analog AM Stereo to the point where it never really fully took off and is repeating itself with the adoption of digital radio.

A base system should be analog only and if digital is to be broadcasted then the analog TX/RX path should be as amplitude flat and phase linear as posible within the passband so a digital decoder could be plugged into it or the digital signal could be fed into a computer's soundcard for decoding. The best system for this would be a Linear ISB system e.g QuAM with 90° audio phase shift differental applied between the I & Q channels. This would offer 2 completely isolated channels during transmittion for ISB Stereo, 1st & 2nd audio channels, 2 data channels, or 1 analog and 1 data channel.