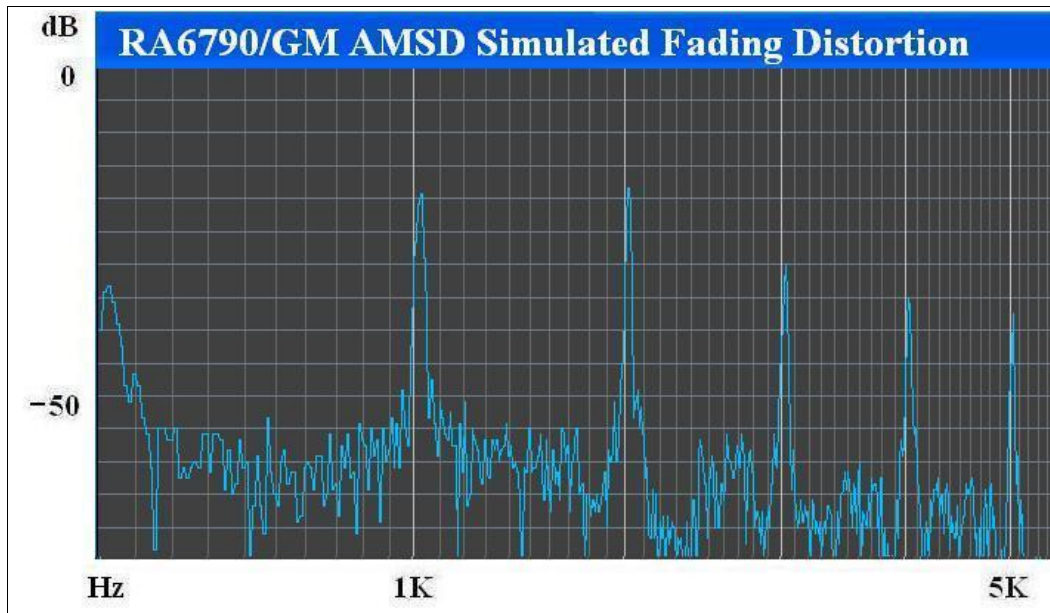


My Experiences With Some AM Synchronous Detectors

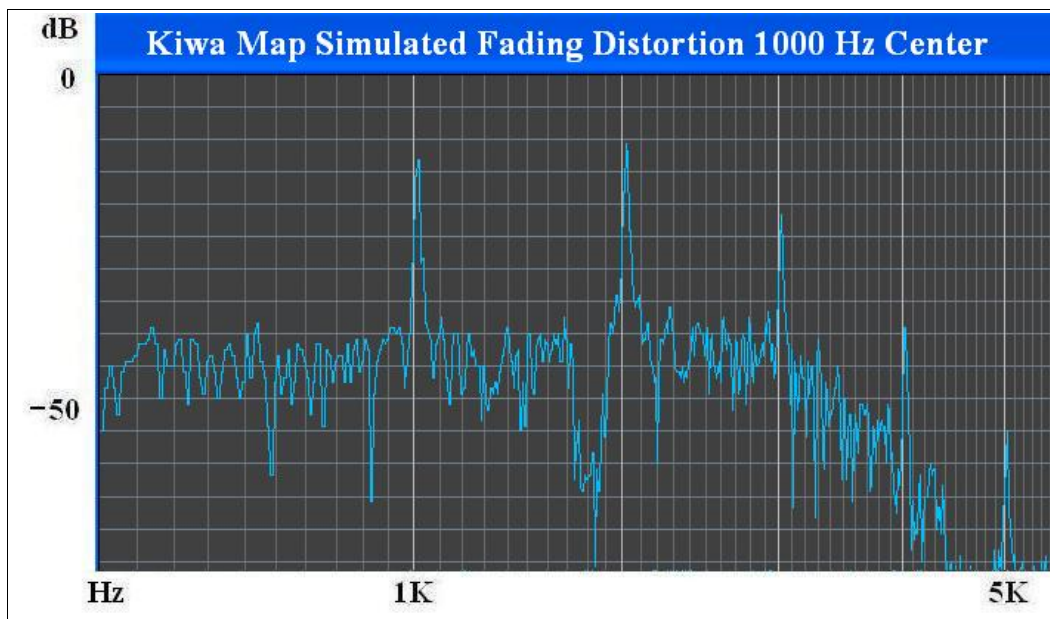
Dallas Lankford, 7/19/06

The more I study and use AM synchronous detectors the more I am mystified as to why they are so highly acclaimed.

First, there is the strange business of RACAL's (6790, 6790, 6830), JRC's (525 and 535's), AMSD-1 and -2, the Kiwa Map unit, and other AM synchronous detectors which do not reduce fading distortion. The Racal and JRC AMSD's are sometimes called quasi-synchronous or synchro-phase detectors, although the Racal manuals refer to them merely as synchronous detectors. Until I learned how to simulate fading distortion and measure it, I thought that perhaps I was imagining that they did not reduce fading distortion. After all, they were AM synchronous detectors, and AM synchronous detectors are supposed to reduce fading distortion. But the spectrum "snapshot" below of a simulated fade leaves little doubt that, for example, the RA6790/GM AM synchronous detector is ineffective against fading distortion. The other AM synchronous detectors above produce similar spectrum "snapshots" of simulated fading distortion. No, I did not imagine it. They really do reduce fading distortion very little, if at all (except for the Kiwa Map unit which reduces some fading distortion via audio filtering). All fading distortion was simulated with a HP-8640B signal generator set for 1000 Hz modulation at 30% and an RF notch filter adjusted for 20 dB fades, with the AM carrier was centered in a 6 kHz nominal filter passband. The signal generator and RA6790/GM were set to 1.000 MHz, and the RF notch filter was inserted between the signal generator and the receiver. The audio results of sweeping the notch through 1.000 Mhz was recorded with a Sony MZ-N510 MiniDisc recorder, and uploaded to a laptop computer using WavePad software. A spectrum analysis of the RA6790/GM audio output during simulated fading was generated using WavePad, and the representative spectrum "snapshot" below was extracted using SnagIt32, a "screen grabbing" program. The fading distortion in this case is composed of harmonics of the 1K Hz fundamental which occurred in this case at 2K Hz, 3K Hz, 4K Hz, 5K Hz and higher audio frequencies (not shown).

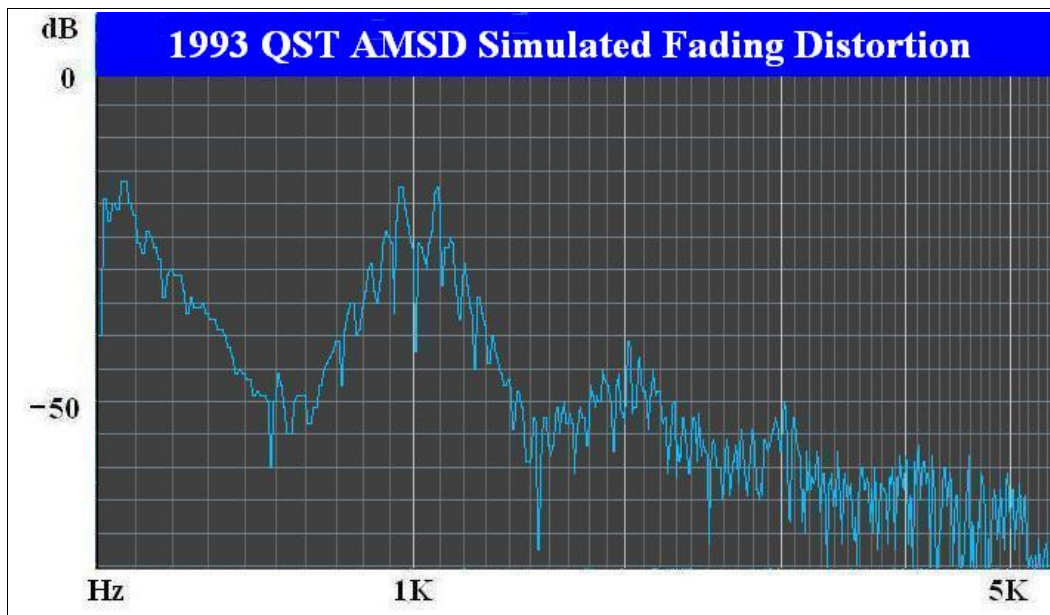


At first when I tested a Kiwa Map unit on fading AM signals it sounded to my ears like it reduced fading distortion as an AM synchronous detector is supposed to. But then I heard distortion on some fades which I didn't think I should hear from an effective AM synchronous detector. So I measured its simulated fading distortion using 1000 Hz modulation. As you can see from the spectrum "snapshot" below the Map fading distortion reduction for a 1000 Hz tone and carrier with the center of the 6 kHz passband is no better than the Racal's and AMSD-1 and -2 at the 2nd and 3rd harmonics, 2K and 3K Hz, though it is better at the 4th and 5th harmonics, 4K and 5K Hz. So why did the Map sound so good on fading AM signals? Clearly it was not due to the Map AM synchronous detector. It turned out to be due to the Map audio filtering! I found that the audio began rolling off fairly quickly at 3 kHz, was down 20 dB at 4 kHz, and down still more at 5K Hz, but impossible to measure accurately because of spurious responses.



It appears, however, from the noise floor of the spectrum “snapshot” that the Map audio filter is down about 30 dB at 5K Hz. This is similar to one of my 4 kHz bandwidth [ELPAF's](#) (elliptic low pass audio filters), but not as much as one of my 3 kHz bandwidth ELPAF's. Both the Map unit and ELPAF's reduce fading distortion (and everything else) outside the passbands of their audio filters. Neither of them has any effect on fading distortion within their respective audio passbands. Of course, fading distortion within an audio filter passband matched to the IF filter of a receiver is much less noticeable than when the fading distortion is outside the audio filter passband.

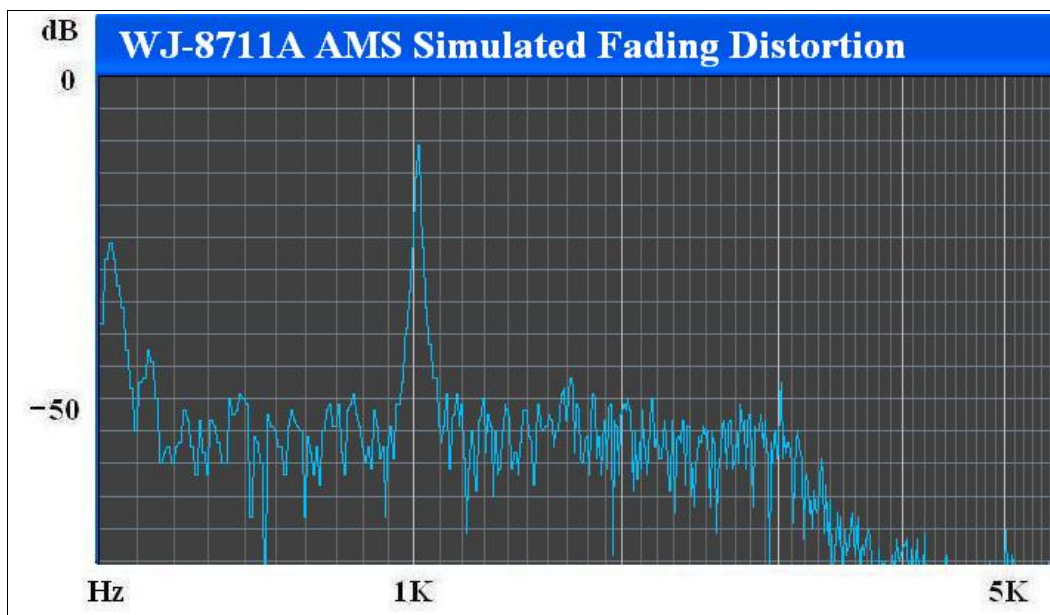
Second, there are AMSD's which do reduce fading distortion, but which regularly lose lock, including the 1993 QST AMSD, the AR7030, the pricy RX-340, and others. The 1993 QST AMSD spectrum “snapshot” below shows that it reduced fading distortion, but in addition to losing lock it also had a new kind of distortion which occurred as sidebands of the fundamental tone. Strange. I have never seen anything like these distortion sidebands before. The distortion sidebands seemed to me to manifest themselves as an increase in hiss (noise) as the carrier went through



the deepest part of the fade. Also, it can be seen from the spectrum “snapshot” that 2nd and 3rd order harmonic distortion were not as greatly attenuated as for other AM synchronous detectors which reduce fading distortion. For these reasons I found the 1993 QST AMSD unacceptable. When you pay as much as \$4K for a receiver it doesn't

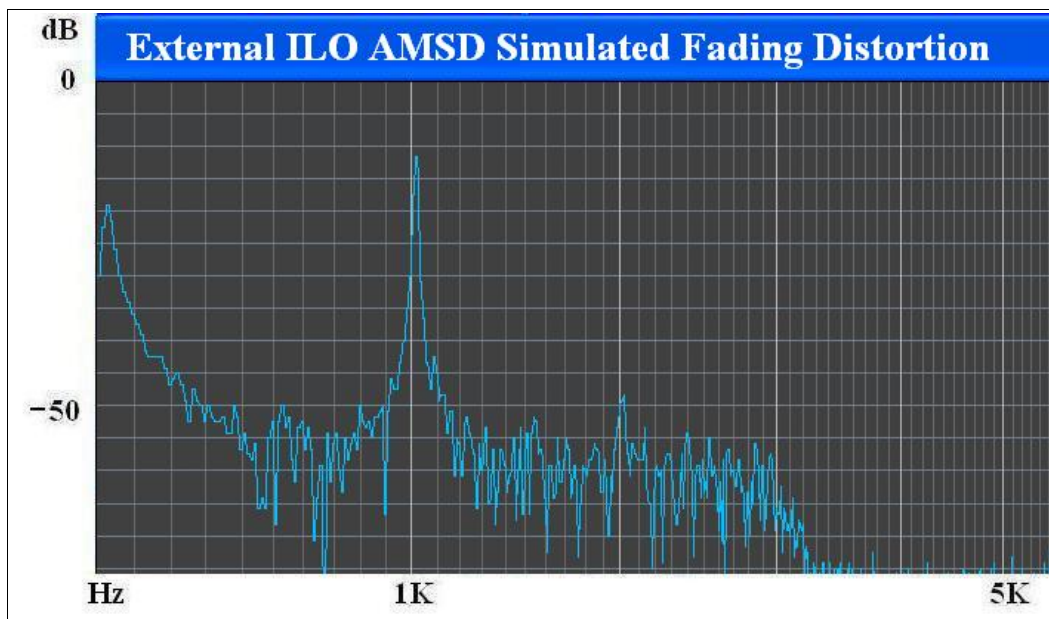
seem to matter to some reviewers whether the AMSD is defective. I have seen several glowing evaluations of the RX-340 AMSD, one with nary a mention of it losing lock and another which said it was great anyway. On the other hand, [Dave](#) has said the RX-340 AMSD is “almost worthless.” I don't plan to spend over \$4K to get first hand knowledge about the RX-340 AMSD. The AR7030 has three (3) AMSD modes, namely AUTO, manual WIDE, and manual NARROW. The manual WIDE mode loses lock on almost every moderately deep fade, which makes it worthless. The AUTO and manual NARROW are both narrow AMSD's, and both sometimes lose lock briefly on quick deep fades. The AUTO mode of my 7030 failed to lock on some graveyard MW channels with multiple signals and on some very weak SW signals near the ambient noise floor. The 7030 AMSD also has a weak tone, like a het, which can be heard on all reasonably strong and clear signals and which varies with the main tuning and passband shift tuning. For those reasons I regard the AR7030 AMSD as unacceptable.

Third, there are AMSD's which do reduce fading distortion, and which do not lose lock or rarely lose lock when properly tuned, which include the Drake R8B, the WJ-8711A, and the original and new R-390A injection locked oscillator AM synchronous detectors (ILO AMSD's) and the new external stand alone ILO AMSD's. The original R-390A ILO AMSD is described in [HSN #17](#). The new R-390A ILO AMSD is in [The Dallas Files](#). The stand alone ILO AMSD's are still under development, but it seems appropriate to make information about them available [here](#) at this time. The R8B can be adjusted to lock with the AM carrier positioned anywhere in the filter passband by using the R8B PASSBAND OFFSET control. However, there has not been universal agreement on whether the R8B loses lock when properly tuned. At least one person has said the following. “The pitch of a sustained musical note will change while using the Drake [R8B] synchronous circuit. This happens when the signal is subject to fading and the circuit attempts to maintain lock. It is most noticeable on musical shows, naturally. The note sounds as though it's being lowered a semitone or sometimes even more - in other words, the music sounds as if it's going a bit flat or 'sour'.” Other R8B owners, including me, have not heard such a pitch change after the R8B AMSD locks. Maybe some R8B AMSD's exhibit this tone pitch variation and some don't? The R8B also has selectable sideband AM synchronous detection which is enabled by pressing the USB or LSB push button while in AM SYNC mode. The WJ-8711A AM synchronous detector is a pleasure to use. It is easy to tune, doesn't lose lock, and has a quite wide lock range, several hundred Hz on each side of the received carrier. The WJ-8711A AMSD locks only when the AM carrier is approximately in the center of the filter passband, i.e., when the WJ-8711A is tuned to the carrier frequency of the received signal. I do not regard that as a design flaw because there is no need for selectable sideband AM synchronous detection. Below is a “snapshot” of WJ-8711A fading distortion. The other AM synchronous detectors above which do reduce fading distortion, and which do not lose lock when properly tuned,



produce similar spectrum “snapshots” of simulated fading distortion. No, I did not imagine it. They really do reduce fading distortion. It has been a while since I owned a Drake R8B, but as I recall, its AM synchronous detector worked as well as the WJ-8711A, some would say better because the R8B included selectable sideband AM synchronous detection as well as operable passband shift in AM synchronous detection mode.

The old and new R-390A ILO AMSD's and the external ILO AMSD I occasionally lost lock because of the difficulty of tuning the ILO correctly in those cases. The external ILO AMSD II can be tuned much more accurately and so rarely, if ever, lost lock. There have been several occurrences where the external ILO AMSD II may have lost lock. For some of these occurrences a second weaker signal was present within about 20 Hz of a stronger signal. It appeared that during deep fades when the amplitude of the weaker signal was appropriate, the ILO briefly, ever so briefly, locked onto the interfering carrier, causing a momentary growl. But the growls could have been normal low frequency hets which were enhanced by the fade. I am inclined to think that lock was not lost because there was no change in the tonal quality of the recovered audio. For other similar occurrences it seemed that extremely fast and deep fades briefly pulled the BFO frequency. A third variation, external ILO AMSD III, using a highly stable series tuned Colpitts BFO oscillator with additional buffering has not lost lock on difficult signal situations such as those mentioned above. Below is a spectrum "snapshot" of simulated fading distortion for the external ILO AMSD. As can be seen, the ILO AMSD performed about as well as the WJ-8711A on the simulated fading distortion.



All of the discussions above are for signals whose carriers are at about the center of the IF filter passband. As discussed above, in those cases some (but not all!) AM synchronous detectors reduce fading distortion compared to ordinary (diode) AM detectors. However, for AMSD's which reduce fading distortion, it seems to be not well known that there is little, if any, audible difference in distortion reduction and recovered audio quality between these fading distortion reducing AMSD's when used in selectable AMSD sideband mode and ordinary (diode) AM detectors when the carrier is off tuned (as far as possible consistent with good audio) to one side or the other of the filter passband (i.e, single sideband AM, as opposed to ECSS). When a receiver is off tuned as far as possible without attenuating the carrier, the recovered audio bandwidth is almost doubled. So if adjacent channel interference is increased when off tuning, a narrower bandwidth should be used. In addition, good audio filters, like [ELPAF](#), do an excellent job of reducing fading distortion and other forms of distortion and together with off tuning and an appropriately slow AGC make AM synchronous detectors which reduce fading distortion generally superfluous

There are other AM synchronous detectors which have not been discussed in these notes, such as the HF-1000(A), SE-3, R-75, and so on because I have not used them, and the R8, R8A, and so on because I don't remember how well or not so well their AMSD's performed. In any case, I do not believe their performance or lack thereof would be surprising or change the conclusions of this article.

The bottom line? The more I study and use AM synchronous detectors, the more I am mystified as to why they are so highly acclaimed.