WJ-8711A Microprocessor Noise Fix & Impressions

Dallas Lankford, 6/10/04, rev. 8/19/05

My new WJ-8711A just arrived (4/21/04). I haven't done much more than unpack it and turn it on. There is microprocessor (uP) noise at the higher SW frequencies just as I expected, but nice and quiet in the MW band. I noticed that the preamp is automatically deactivated below 500 kHz. Why? Maybe there is a way to override that. The uP noise at higher SW frequencies appears to be associated with touching or coming near the tuning knob. So the fix appears to be the same as I did for my Racal RA6830's when I changed over to metal spin knobs (and the same as the static cure for the R8 and the 51J-4), namely ground the shaft with a tension washer and grounded wiper.

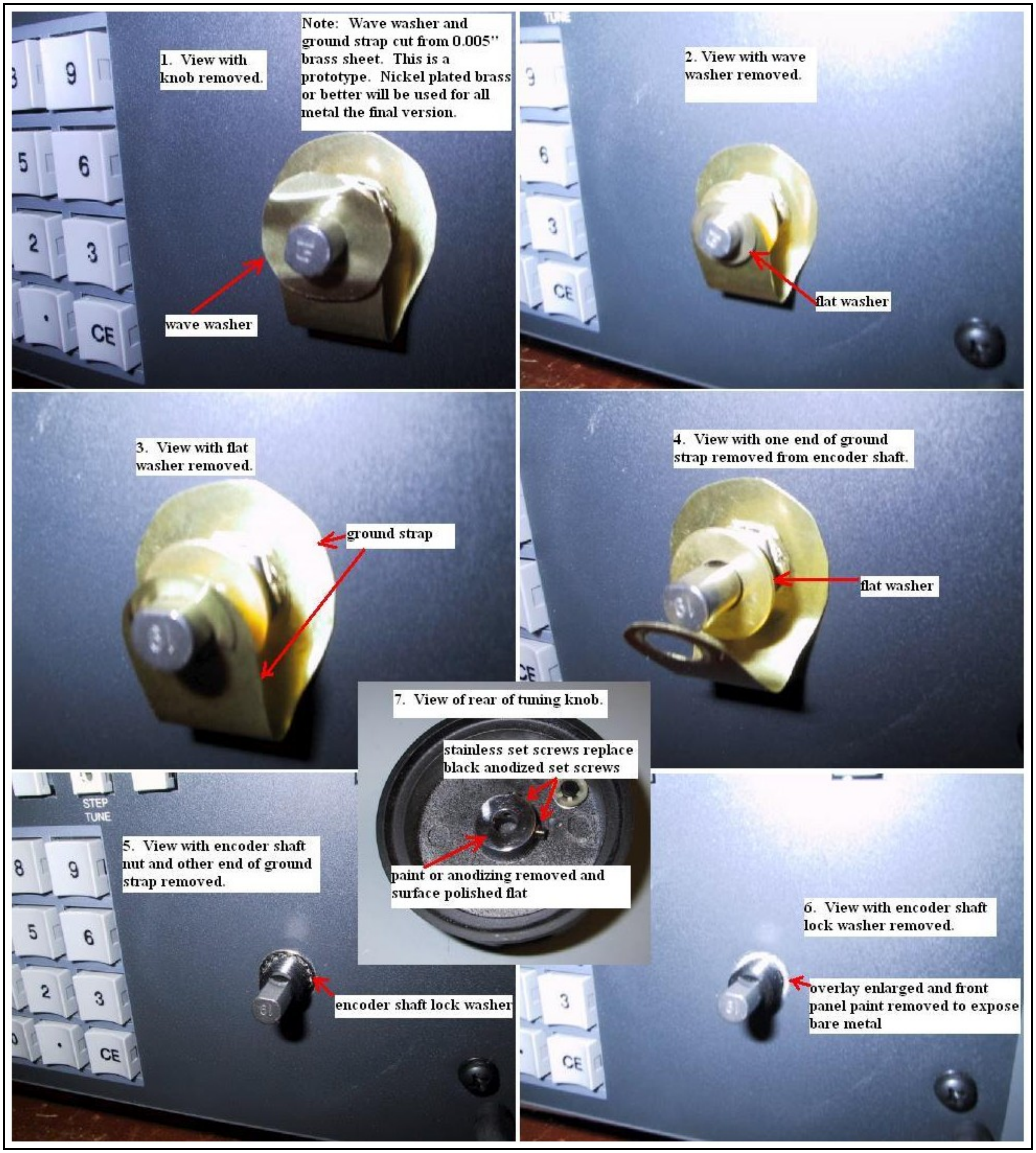
Yep. It is just as I suspected… the same problem my Racals had, and the cure is the same. Well, not quite. I don't want to go drilling holes in the 8711A front panel. They might void the warranty. The front panel is a plastic overlay, and the encoder bushing is plastic. But there is a stainless nut and stainless internal tooth lock washer on the encoder bushing. So I got out my X-Acto knife, put a new blade in it, and (very carefully) traced around the circumference of the lock washer. I had to do this several times to get down to metal. The tiny annulus of plastic came out, and I used my pen knife (small pocket knife) to scrape away the paint where the annulus had been. When I put the washer and nut back on, you couldn't tell anything had been done to the 8711A. It looked just like it did before. But now the washer and nut were electrically connected (grounded) to the front panel. I used some 0.005" brass sheet to form a "wrap around" from the nut and washer to the shaft. A ¼" hole was made (using a standard ¼" paper punch) in one end of the wrap around (to slip over the shaft) and a 3/8" hole was made in the other end (to slip over the encoder bushing). The 3/8" hole was made by first punching a ¼" hole, and then enlarging it to 3/8 " with a Dremel tool conical grinding wheel. It was deburred with a disk cutoff wheel. Then the nut came off, the wrap around was slipped onto the encoder shaft, the nut was tightened (don't over tighten because the bushing is plastic), a ¼" flat bronze washer was put on the shaft, then the other end of the wrap around was put on the shaft, then another thin flat washer was slipped onto the shaft, then a "wave washer" (made from the same 0.005" brass sheet) was slipped onto the shaft, and finally the knob was slipped onto the shaft (compressing the wave washer), and finally the shaft set screws were tightened. Like I said, no more uP noise. When I make this mod permanent, I will tin the brass part to insure good long term electrical contact. Oh, two more things. The inside rear of the knob where the shaft inserts into the knob is painted black, or has some kind of black finish. Very pretty. But not seen when installed. And non-conductive. Again, using my Dremel tool, I ground off the black whatever by sticking the set screw (which is at the center of the disc) into the knob shaft hole and letting the flat part of a cutting disk grind off the black stuff. Then I polished the bare metal to a mirror finish (to minimize friction and wear). Finally, the Allen (hex) set screws were black anodized, also non-conductive, so they had to go. Moreover, these pretty black set screws always rust as time goes by. I replaced them with stainless steel. The threads in the knob are bare metal, so the knob, shaft, and everything else are grounded to the tiny annulus of bare metal that I made where the encoder bushing comes through the front panel.

Neat, huh? Below are some photos of the mod.

Now my brand new WJ-8711A is the only WJ-8711(A) (or HF-1000(A)) that is microprocessor noise free. Well, that is not entirely true. I still can't put a passive or active antenna anywhere near the 8711. But then I can't put an antenna near my Racals or Harrises either. Incidentally, the antennas of my phased array are 100 feet distant from my receivers, and the feed lines are (balanced) twin lead (which generally has less pickup than coax).

Just finished measuring the AM sensitivity at 1.6 MHz (usual parameters). 1.0 uV with the preamp on and 1.3 uV with the preamp off. They may as well have left the preamp out. I am tempted to go after that tomorrow, but it would void the warranty for sure. Of course, a little thing like that…

Do I like the WJ-8711A? You bet. It has the best frequency display I have seen. And the other LED displays are excellent too. The tuning knob is identical to the Racal RA6778C knob, but finished differently (black anodized or powder coated). It has a nice heavy feel to it, and an attached dimple (quite large) for spinning with your finger. The 8711A seems very intuitive and easy to use. The frequency entry, step change, and other features are simply the best of any receiver I have used. I suppose you can customize the BW's for each mode, but I probably won't bother because it is so easy to select a BW different from the factory default with the push button selected rotary knob (which, with other push buttons, is also used to select mode, AGC release time, noise blanker setting, and so on). It appears to have 100 memories, but I haven't used that feature yet. There are separate audio level knobs for the headphones and speaker. Very nice. The manual specifies 2 Vrms into 8 ohms (1/2 watt) for the speaker output, but I measured 3.5 Vrms (1.5 watts into 8 ohms), and an audio BW of at least 100 Hz to 13,000 Hz at less than 3% harmonic distortion. Connected to a good speaker, it sounds excellent to me. Headphone output through a ¼" stereo headphone jack (stereo for ISB, L and R common in all other



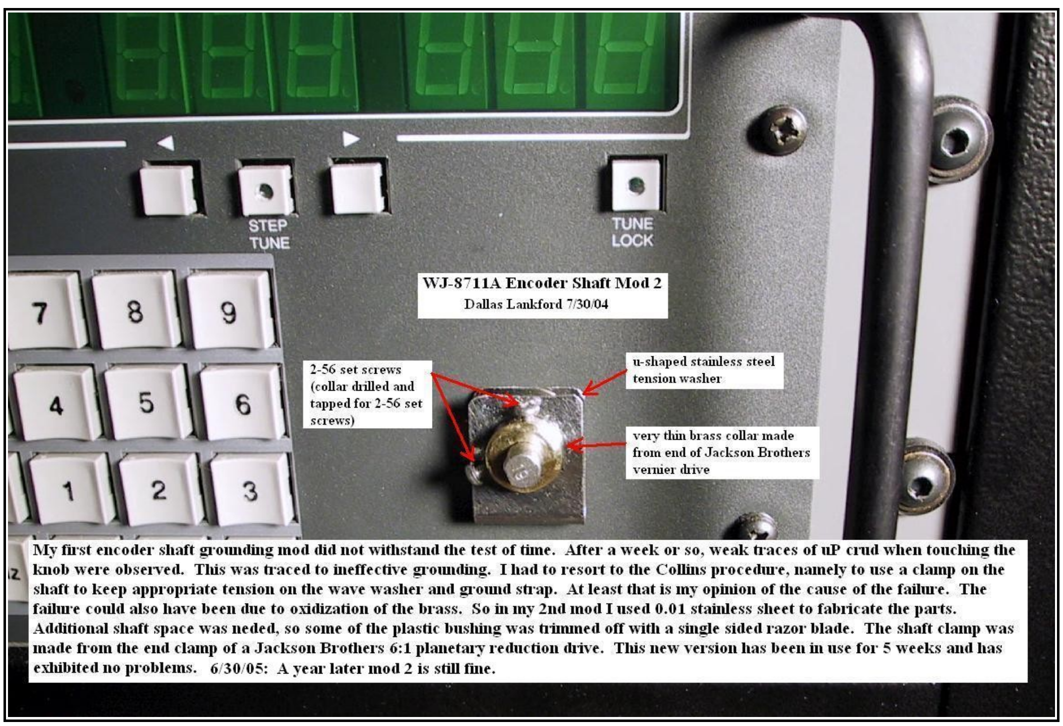
modes) is specified as 10 mW (presumably rms) into 600 ohms, no BW given. Low impedance headphones seem to work fine. Pressing the special function key repeatedly toggles you through various user selectable parameters. In particular, it allows you to choose the release (decay) times for fast, medium, and slow AGC. You don't have complete freedom to choose, but 10 – 100 mS for fast, 100 to 1000 mS for medium, and 1 – 5 seconds for slow. I reset mine to 100, 1000, and 3. I haven't had any hets yet, but the (presumably manual) notch filter is there if you need it. And yes, there is AM synchronous detection if you want it. It is the only feature of the 8711A that is not well implemented. A good AMSD should be transparent to the user, i.e., never lose lock, and lock instantly to the strongest carrier in the passband. The AMSD of the 8711A does not meet these requirements. However, since most people can't tell the difference between a good slow AGC release time and a good AMSD, it doesn't really matter. The 3 second release time I chose for my slow release takes care of strongly fading SW and MW graveyarders. And in the rare event that it won't, the 8711A manual gain control is excellent for those occasions. Tuning around in CW mode with no antenna connected, I did not find any internally generated spurs from 150 kHz to 10 MHz where I got tired of spinning the knob. I did find one at 125 kHz or thereabouts. This WJ-8711A is the most spur-free receiver I have ever tested, bar none. I wish I could say the same about the LO's, or perhaps it is the DSP circuits. I don't really know. But tuning around near a carrier produces all sorts of weak birdies. Most of these are within about +/- 20 kHz of the carrier. But there were additional (presumably 1st LO) spurs at about +32.5, +72.5, … and -47.5, -87.5, …kHz from the carrier, decreasing slowly in level. These correspond to phase noise of about -127 dBc/Hz when using a 6 kHz BW. So they are not really a serious issue, though I would like to see better LO performance in a receiver of this caliber. It is possible that they are spurs of the internal frequency standard. I'll check this later. I have been running the 8711A head to head against one of my R-390A's on some weak signals, and it is almost a dead heat. I am very pleased with it.

6/9/04

Now that I have had the WJ for about 6 weeks, I understand its pluses and minuses a bit better.

The uP noise above 20 MHz is extremely difficult to tame. When using folded dipoles cut for 15 meters and located about 10 meters away from the 8711A, depending on how the 8711A and R-390A are grounded, the 8711A can (and does) introduce some very weak uP crud into the R-390A when the R390A tuning knob is touched, or when my hand or body comes near the 8711A AGC / BFO / BLANKER display. Most of these residual uP crud problems have been eliminated by using (single) Faraday shielded isolation transformers with balanced outputs, one for each of the R-390A and WJ-8711A, with separate earth grounds. An added benefit of this arrangement is that the isolation transformers greatly reduce some bad man-made noise at the low end of the MW band and high end of the LW band which originates at my next door neighbor's house and tends to show up every evening around sundown. But one should not have to go to these extremes to eliminate RFI originating in a $5K+ receiver. The problem should have been eliminated during the R & D.

My encoder shaft grounding mod above did not withstand the test of time. After a week or so, weak traces of uP crud when touching the knob were observed. This was traced to ineffective grounding. I had to resort to the Collins procedure, namely to use a clamp (collar) on the shaft to keep appropriate tension on the wave washer and ground strap. At least that is my opinion of the cause of the failure. The failure could also have been due to oxidization of the brass. So in my 2nd mod I used 0.01 stainless sheet to fabricate the parts. The side of the U shaped stainless steel washer nearest the front panel (see below) was grounded to the front panel



with the external tooth stainless steel lock washer and stainless steel encoder shaft nut. Additional shaft space was needed, so some of the plastic bushing was trimmed off with a single sided razor blade. The shaft collar was made from the end clamp of a Jackson Brothers 6:1 planetary reduction drive. This new version has been in use for about a year and has exhibited no problems.

Various DXers have talked about hearing signals on one receiver that they can’t hear on another, with all other things being equal. This, in turn, causes them to rate one receiver above the other. These cases have been reported for signals out in the open (no adjacent channel interference) and for signals with strong adjacent interference. I have never observed this. I have top receivers that occasionally (rarely) hear a signal better than another top receiver, but never hear a signal on one and not hear the same signal at all on the other. Also, the tables are invariably turned. That is, occasionally (rarely) the other receiver hears a signal better than the one. I have now spent dozens of hours comparing the WJ-8711A to an R-390A on weak signals in the open (for example, Australia on 21.740 in the early evening hours, Australia on 2385, 2325, and 2310 from first light to after dawn, and R. Huayacocotla MEX 2390 (about 800 miles distant) from about 7 a.m. to 9:30 a.m. local time. Using manual ECSS the 8711A and 390A are about equal. Using AM, the 390A produces clearer audio, especially at the noise floor during fades. With the 8711A using AMS and the 390A using AM, they are about equal. But since the 8711A AMS must be tuned with the carrier centered in the passband, the overall edge goes to the 390A.

What about other top receivers? Because it has fewer spurs, I would rate the 8711A slightly ahead of the NRD-525 in that category. However, the 525 AM detector is AMS by default (JRC calls it DSB), and it works wonderfully with the carrier anywhere in the passband, provided one suitably modifies the 525 AGC, so the overall edge goes to my AGC modified 525's. 7/28/06: But, as I discovered only recently, the 525 AMS does not reduce fading distortion, do there is no basis in fact for ranking the 525 ahead of the 8711A.

The 8711A is 3rd in my rankings at this point in time. It will probably end up 4th because I am currently evaluating a modified ICOM IC-746Pro (MW & LW attenuator removed and preamp enabled below 1.6 MHz) and it appears the 746P will move into the #2 slot.

However, I should emphasize that these differences are slight, and other people might very well come to a different ranking.

Here are a few things that put the 746P at the top of the heap. The AM detector is an AM synchronous detector. Why ICOM doesn’t advertise this feature of the 746P is a mystery to me. I discovered it merely by noticing that it sounded like an AM synchronous detector and asking ICOM Technical Support if it was. They confirmed what my ears had already told me. And it is not just any old AM synchronous detector. It is outstanding. It doesn’t lose lock, no growling, and you can tune the AM signal with the carrier anywhere in the passband you please. In other words, the 746P AMSD is completely transparent to the user. You never know it is there except that the quality of AM reception is better than with an ordinary AM detector, and better than ECSS.

But curiously now (June 2005), according to some information which was sent to me from unverified sources, another ICOM Technical Support person has stated that the 746Pro AM detector is not an AM synchronous detector. What do I think? I think that if it walks like a duck, quacks like a duck, and flies like a duck, then it is a duck. 7/28/06: But then again, perhaps not all ducks are ducks. Based on recent experiences with elliptic low pass audio filters, it seems entirely possible to me that ICOM used DSP audio filtering in the 746P to eliminate most AM fading distortion. Without access to the 746P DSP code it is impossible to determine exactly what ICOM has done with the AM mode of the 746P.

The 746P 1st LO oscillator phase noise (or more generally the composite noise) at close separations (from 3 to 10 kHz) is better than -120 dBc/Hz. This is easily 10 dB better than any other solid state receiver that I am familiar with… including such receivers as the NRD-525, 535, and 545, the RA6790/GM, 6793, and 6830, the (Harris) RF-590, and 590A, the 651S-1 and HF-2050, and the HF-1000(A) and WJ-8711A. The filters ultimate attenuation is greater than 86 dB, and even though there are only three AM filters, their bandwidths are well chosen. There are three fixed AM filters, nominally 3, 6, and 9 kHz BW, and the operator cannot change the BW’s or shapes. I haven’t measured the “9” BW filter, identified as #1 on the 746P display. I have measured the other two: #2 (6 kHz nominal): 6.7 @ - 6 dB, 12 @ -60 dB, 18 @ -80 dB, ultimate~ -86 dB, and #3 (3 kHz nominal): 3.4 @ -6 dB, 7.0 @ -60 dB, 110 @ -80 dB, ultimate ~ -86 dB. This is about as good as it gets. The down sides are that the ICOM included a 10 or 11 dB attenuator in the signal path below 1.6 MHz and the preamps are disabled below 1.6 MHz. Furthermore, Preamp 1 gain rolls off fast below 500 kHz. And it is non-trivial to fix these things because of the many tiny 0603 SMD’s and tiny PC board traces. But they are fixable.

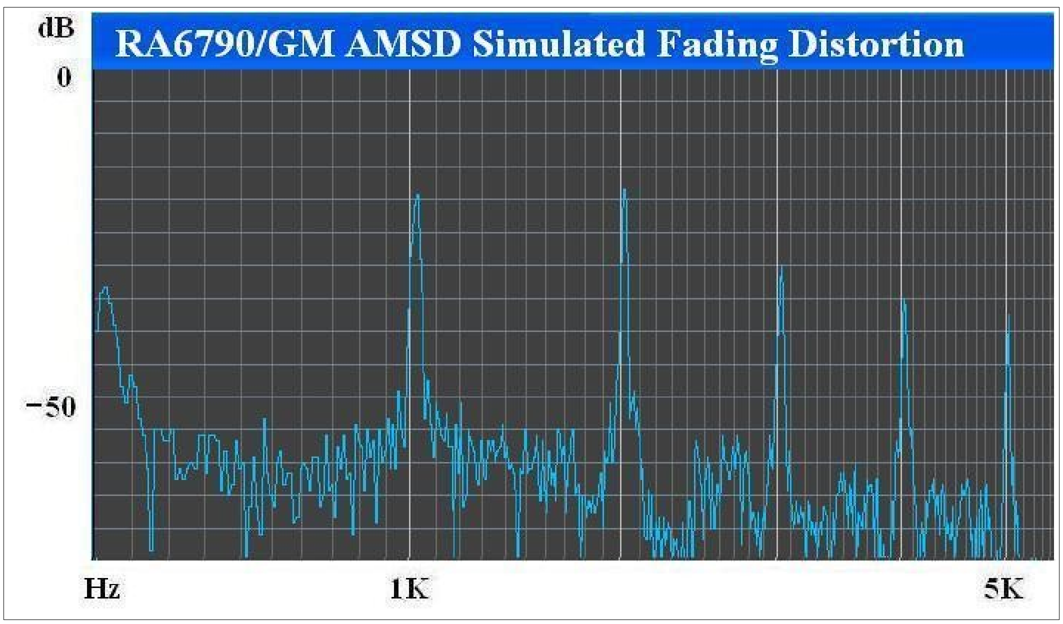
But all of the above rankings became moot when I discovered about a year later how to simulate and measure fading distortion as described in the Appendix below. As it turned out, some AM synchronous detectors are better than others, much better, and the WJ-8711A AM synchronous detector is at the top of the heap in that regard. So for some DXers this changes the ranking significantly, placing the WJ-8711A in first place. This also shows how our opinions can be strongly influenced by peer pressure based on popular misconceptions.

Appendix

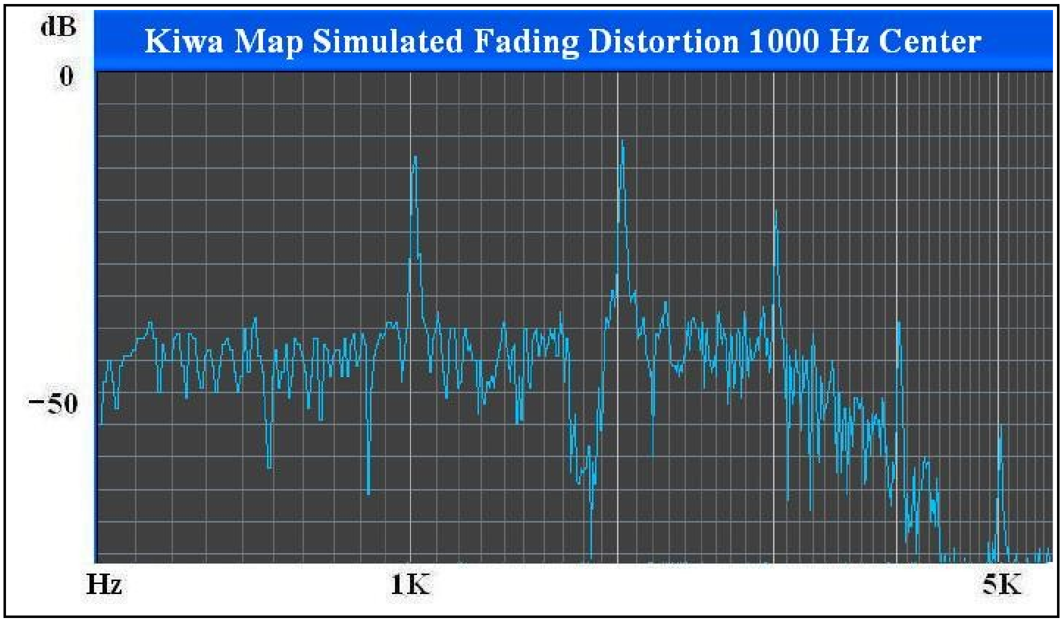
My Experiences With Some AM Synchronous Detectors

Dallas Lankford, 7/19/06, rev. 12/23/07

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, 6793, 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 (although curiously some have claimed they do). 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 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

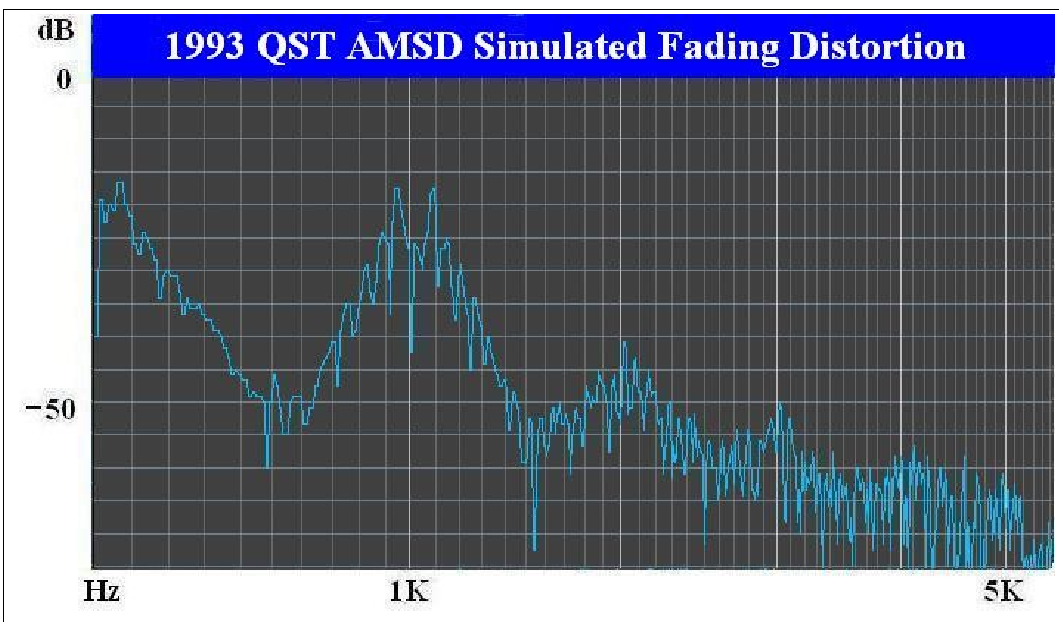


was inserted between the signal generator and the receiver. The audio results of sweeping the notch through 1.000 Mhz were recorded with a Sony MZ-N510 MiniDisc recorder, and uploaded to a laptop computer using WavePad FFT software. Spectrums of the RA6790/GM audio output during simulated fading were generated using the WavePad FFT software, 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 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



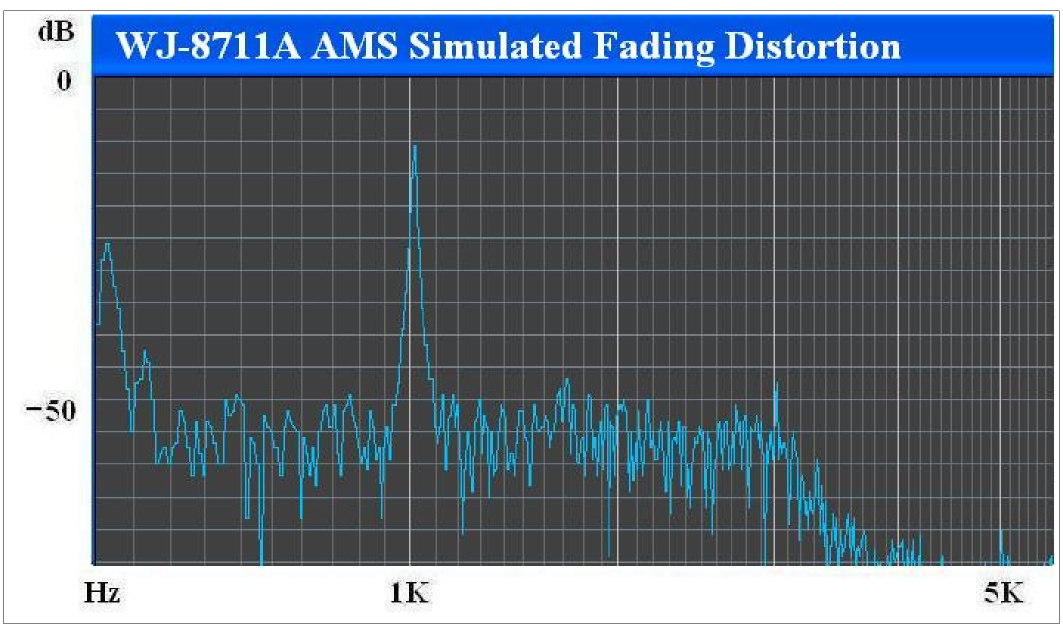
4 kHz, and down still more at 5K Hz, but impossible to measure accurately because of spurious responses. It appears, however, from the noise floor of the spectrum "snapshot" that that the Map audio filter is down about 30 dB at 5K Hz. The audio filter shape of the MAP in this case is similar to one of 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. That's why the Map sounds so good.

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



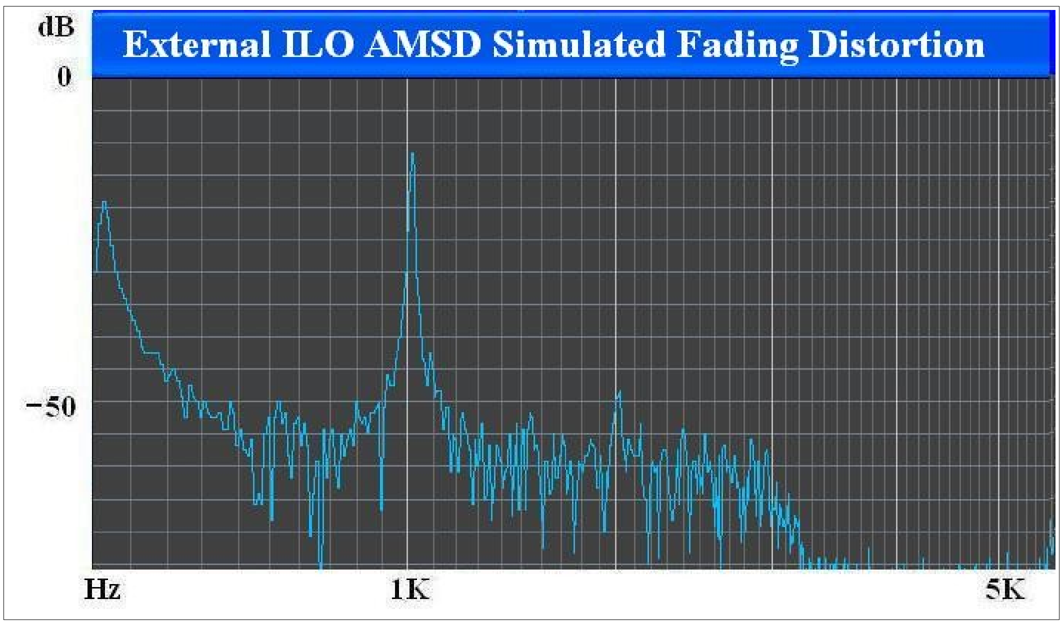
the fundamental tone. Strange. I have never seen anything like these distortion sidebands before. The distortion sidebands seemed to me to manifest themselves as an increase in hiss (noise) as the carrier went through the deepest part of the fade. Also, it can be seen from the spectrum "snapshot" that 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 of 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 have not been published 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 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. If adjacent interference makes it desirable to tune only one sideband, ECSS (USB or LSB, whichever is appropriate) is usually a better choice. Above is a "snapshot" of WJ-8711A AMS 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 detetors. 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.