NRD-525: A Technical Review

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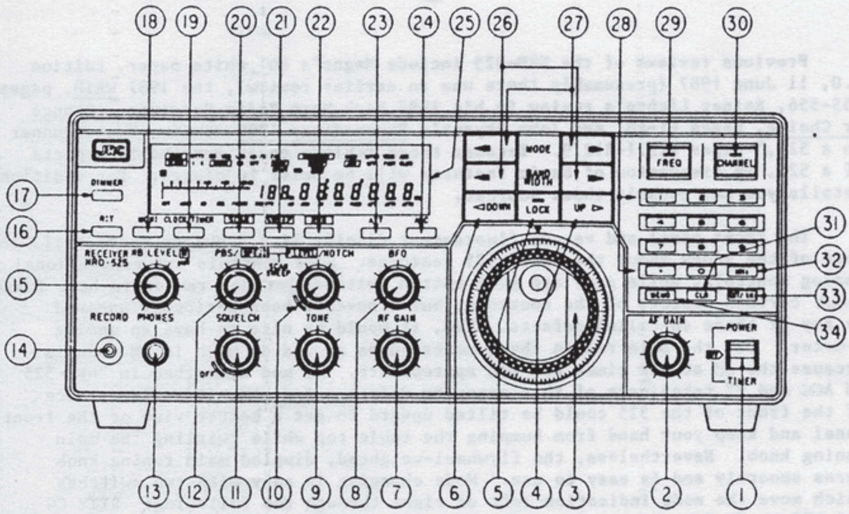
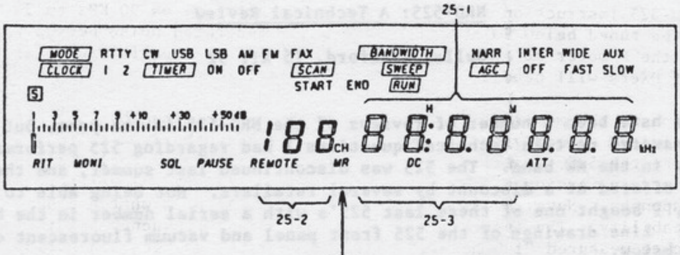
There have been a number of reviews of the NRD-525 in the past, but none of them answered certain technical questions I had regarding 525 performance, especially in the MW band. The 525 was discontinued last summer, and the remaining stock was offered at a discount by several retailers. Not being able to resist a bargain, I bought one of these last 525's with a serial number in the high 51,000's. Line drawings of the 525 front panel and vacuum fluorescent display are given below.



Front panel

1 POWER TIMER ON OFF switch
2 AF GAIN control
3 TUNING control (This control also works as RIT control when characters "RIT" are on)
4 UP switch
5 LOCK switch
6 DOWN switch
7 RF GAIN control
8 BFO control
9 TONE control
10 NOTCH control (It also works as P LEVEL (pause level) control during scan or sweep reception)
11 SQUELCH control
12 PBS (pass band shift) (It also works as the SPEED control during scan or sweep reception)
13 PHONES jack
14 RECORD jack
15 NB LEVEL (noise blanker level) control
16 RIT switch
17 DIMMER switch
18 MONI (monitor) switch
19 CLOCK TIMER switch
20 SCAN switch
21 SWEEP switch
22 RUN switch
23 ATT (attenuator) switch
24 AGC control
25 Vacuum Fluorescent Display (VFD)
26 BANDWIDTH switch
27 MODE switch
28 Numerical keys
29 FREQ (frequency) switch
30 CHANNEL switch
31 CLR (clear) switch
32 MHz switch
33 ENT kHz switch
34 MEMO (memory) switch



(25) Vacuum Fluorescent Display (VFD)

Previous reviews of the NRD-525 include Magne's RDI white paper, Edition 2.0, 11 June 1987 (presumably there was an earlier review), the 1987 WRTH, pages 555-556, Rainer Lichte's review in his 1987 book More Radio Receiver - Chance Or Choice, pages 41-48, and John Bryant's Proceedings 1989 review, "Wastegunner on a 525," pages R12.1-R12.9. Because these reviews cover most basic aspects of a 525, my discussion of basic features will be brief in places. For additional details you may consult those sources.

The front panel and vacuum fluorescent display line drawings above tell most of the story about the basic 525 features. Some controls are conventional analog controls, while some are push button switches. Other reviewers have fussed about certain aspects of the controls, but I haven't been seriously annoyed by any of these so-called defects. Yes, it would be nice to have an analog S-meter. But the main reason the S-meter jumps around so much in AM mode is because the AM attack times are not appropriate. My mod described in "NRD-525 AM AGC mod 2" takes care of this annoying defect. And yes, it would be nice if the front of the 525 could be tilted upward to get a better view of the front panel and keep your hand from bumping the table top while twirling the main tuning knob. Nevertheless, the flywheel-weighted, dimpled main tuning knob turns smoothly and is easy to use. Mode changing is easy with two switches which move the mode indication left or right through the following: RTTY CW USB LSB AM FM FAX. By contrast, with the R8 you have to cycle completely through all other modes to get back to the one you want. Similarly, bandwidth changing is easy with two switches which move the bandwidth indication left or right through NARR INTER WIDE AUX. Changing the AGC setting is not as convenient; a single switch cycles through OFF FAST SLOW. In addition to tuning with the main tuning knob, a frequency can be entered either in KHz or MHz using the keypad, and the frequency can be changed with the UP and DOWN switches.

Some operating aspects of the 525 can be changed by the user. The tuning rate of the main tuning knob and the step increment of the UP and DOWN switches can be changed between "coarse" and "fine" by pressing the RUN switch. In "fine" tuning mode, the main tuning knob rate is 2 KHz per revolution and the UP/DOWN increment is 1 KHz, while in "coarse" tuning mode the rate/increment is 20 KHz/10 KHz. The 10 Hz digit of the frequency display can be turned "off" and "on" by pressing MEMO and 1 switches simultaneously. And the frequency indication in USB and LSB modes can be changed between "automatic" and "manual" modes by pressing MEMO and 0 switches simultaneously. In "automatic" mode the frequency display does not change when changing between USB and LSB (and you do not have to retune).

The NRD-525 Instruction Manual gives the tuning range as 90 KHz to 34 MHz. The 525 can be tuned below 90 KHz, but internally generated noise begins to register on the S-meter at about 70 KHz, so the 525 is not useful much below 90 KHz. VLF DXers will need to use a VLF converter.

In the past, the merit of a receiver was often determined by the three S's - sensitivity, selectivity, and stability. With synthesized solid state receivers like the 525, stability is seldom an issue. Consequently, a more appropriate modern version of the three S's is sensitivity, selectivity, and spurious responses. Nevertheless, for completeness, here is what has been published about 525 stability. The instruction manual specifies "Frequency stability ±3 PPM." Lichte measured "± 5 Hz/hr," while Magne reported "less than ±10 Hz at 10 MHz, excellent." I don't have the equipment to make such precise drift measurements. Suffice it to say that I haven't observed any drift with the 525's I have used, and I don't expect to observe any.

Sensitivity should not be an issue for modern solid state communications receivers, but surprisingly it sometimes is. Some receivers, like the R-5000, are desensitized in the MW band by design. Others, like the R8, are not quite sensitive enough throughout the entire tuning range. Both Magne and Lichte stated that the 525 sensitivity is derated in the MW band. Lichte even provided values of 16 and 19 microvolts at 1000 and 500 KHz respectively for a 10 dB S+N/N using the WIDE bandwidth and AM mode, compared to 2 microvolts for the SW bands. In addition, the 525 instruction manual specifies 15 microvolts or better sensitivity for the 0.90-1.6 MHz frequency range, and 2 microvolts or better for the 1.6-34 MHz frequency range using AM mode. However, I do not know of any 525 with worse sensitivity below 1.6 MHz than above. As a matter of fact, the sensitivity of my 525 is about 0.35 microvolts throughout the MW band for a 10 dB S+N/N using WIDE bandwidth and AM mode, with a 400 Hz modulated source at 50% modulation. The WIDE bandwidth AM sensitivity of my 525 on the SW bands is not quite as good, about 0.45 microvolts, but still excellent. Perhaps some early production 525's were desensitized by design in the MW band. But that appears not to be the case for most 525's. The 525 is one of the few solid state receivers with adequate MW band sensitivity at locations like mine with low levels of man-made noise.

Selectivity should also not be an issue for modern solid state communications receivers, but again it sometimes is. Insufficient number of bandwidths, and inappropriate bandwidths are the common defects. The 525 design is excellent with regard to available bandwidths because it has four available bandwidths which are selectable independent of mode. A 525 comes with three selectivities - AUX, WIDE, and INTER. A fourth bandwidth is available in the NARR position when an optional filter is installed. Unfortunately, no suitable AM filter is currently availavle for the fourth position. So you have to make do with the three stock bandwidths. The instruction manual specifies the AUX, WIDE, and INTER 6 dB/60 dB bandwidths as 12 KHz or more/not specified, 4 KHz or more/10 KHz or less, and 2 KHz or more/6 KHz or less respectively. Typically the WIDE and INTER filter bandwidths are better than specs. For example, mine are 12 KHz/24 KHz, 5.9 KHz/8.3 KHz, and 2.4 KHz/4.2 KHz respectively. These bandwidths are satisfactory for virtually all listening situations, though I would like a 3.0 KHz filter if one was available. In Magne's review it was said that ultimate filter rejection was limited to about 65 dB due to "cross coupling in the matching networks of the IF stage." However, in 525's I have tested, the ultimate rejection has been excellent, typically greater than 100 dB (the limit of my measuring method).

Measurement of ultimate filter rejection was complicated by what seem to be synthesizer noise sidebands and "blips" apparently due to synthesizer spikes. The "blips" were about 86 dB down on my 525 at about ±10 KHz and ±100 KHz from the primary synthesizer frequency in the MW band, and also at ±200 KHz in the SW bands. Weaker "blips" greater than 94 dB down were observed at ±200, ±300 KHz, etc. in the MW band and at ±300 KHz, etc. in the SW bands. To conclusively demonstrate that the "blips" were not due to filter leakage, I injected a signal generator source at the junction of L103 and C19 on the CFH-36 IF FILTER UNIT PC board. Throughout most of the WIDE filter stopband, ultimate rejection was greater than 100 dB (the limit of my test equipment). Only at one point, about 510 KHz, was the ultimate rejection measurable at about 100 dB down.

These synthesizer "blips" and noise sidebands can produce unexpected spurious responses where there should be none. Here is how. Let's say you have a super local on 1520 KHz and you tune to 1620 KHz. The -100 KHz synthesizer "blip" mixes with the super local on 1520 KHz at the first mixer before any significant selectivity and produces a phantom copy of your super local where it should not appear. I don't have a super local close enough to the edge of the MW band to observe this phenomenon on the 525.

Spurious responses due to synthesizer "blips" are not an idle concern. For example, some of the spurious responses I have observed on a Drake R8 are due to synthesizer "blips". Using a signal generator, I determined that when an R8 is tuned to 1490.00 KHz there are synthesizer blips about 85 dB down at 1649.0 and 1849.0 KHz, and a somewhat weaker "blip" at 1759.4 KHz. Sure enough, there was my super local KRUS in the noise at 1649.0 and 1849.0 KHz. The 1759.4 KHz spur could not be observed because of a stronger navigation signal on about 1760 KHz. Previously I had overlooked the 1849.0 KRUS spur because of a 3rd order IMD product on 1850.0 KHz (KRUS+KWKH/2x1490-1130). And I hadn't noticed the 1649.0 KRUS spur, perhaps because man-made noise levels were not low enough on previous spur searches. I have not done a thorough study of the R8 synthesizer "blips", but they appear to occur about ±50 KHz from the primary synthesizer frequency, and at approximately multiples of 100 KHz thereafter. For example, with a signal generator set at 1100 KHz, R8 "blips" were observed at 1153.8, 1253.6, 1352.8, 1453.6, etc. and at 953.8, 853.6 KHz etc.

To measure the levels of spurious responses due to synthesizer "blips" I used a calibrated signal generator with a precision attenuator. The receiver S-meter was first calibrated using the signal generator connected to the receiver antenna input terminal. Then the signal generator was set to a particular frequency, say 1490.00 KHz, and the signal generator output was set for maximum, say 100,000 microvolts. The receiver was tuned above and below the signal generator frequency, and the frequencies and levels of any "blips" were noted. Thus, when I said that "blips" about 85 dB down were noted at 1649.0 and 1849.0 KHz on the R8, what I meant was that S-meter readings equivalent to 85 dB below 100,000 microvolts were observed. The actual synthesizer "blips" themselves were not observed, only their effect, namely the mixing of a strong nearby signal with a synthesizer "blip" to produce a phantom signal where there should be none. This method of measurement simulates precisely what happens in an actual listening situation with an antenna connected.

The NRD-525 produces fewer spurs due to synthesizer "blips" than the R8 because the 525 uses double tuned circuits ahead of the first RF amp which automatically track the received frequency, while the R8 uses switched broadband front end filters. At MW frequencies the 525 is unlikely to produce observable spurs beyond the first pair of synthesizer "blips" ±100 KHz, and the spurs are unlikely to be observable except in the 1610-1700 KHz and 440-530 KHz frequency ranges. The R8 is also unlikely to produce observable spurs due to synthesizer "blips" within the MW band, but clearly does produce multiple observable spurs for 100's of KHz above the MW band and perhaps below the MW band when used with a rather ordinary wire antenna. I don't know if SW signals levels are high enough to cause observable spurs due to synthesizer "blips" on the 525 or R8. If they are, then the 525 might produce such spurs at ±100, ±200, and ±300 KHz from a strong SW broadcaster, and the R8 might produce such spurs up to several MHz away from a strong SW broadcaster. Such spurs are much more difficult to identify at SW frequencies in actual DXing situations because of the transient nature of SW signals due to fading. But it wouldn't surprise me if many SW DXers have chased weak hets which are actually spurs due to synthesizer "blips", especially on R8's and other broadband front end receivers, and perhaps even on 525's.

In addition to spurious responses due to synthesizer "blips" which follow you as you tune around, a 525 also has fixed internally generated spurs. These can be most easily observed by tuning the 525 in USB or LSB modes with no antenna connected. On my 525 there is an S-4 spur at 100 KHz, and weaker spurs about every 100 KHz throughout the entire tuning range. Many of these spurs can be detected with an antenna connected, at least at my location (which has low levels of man-made noise) with a noise reducing antenna (which further reduces man-made noise), provided no received signal is present on the frequency. However, none of these spurs have been observed as a het on a MW band signal, perhaps because these spurs are almost exact multiples of 100 KHz, and are quite weak. There are also some irregular spurs in the MW band on my 525: 548.6, 617, 958, 1026, 1229, 1520, 1523.3, 1524, 1534, 1539.3, and 1560 KHz. None of these irregular spurs have been observed as hets on MW signals, perhaps because they are so weak, or perhaps because I do not have the right combination of suitably weak MW signals on adjacent channels. Both regular and irregular SW spurs are observed when atmospheric and man-made noise are low.

Besides these unconventional spurs which were virtually unheard of before synthesized receivers, the 525 can produce phantom signals via conventional images of the 455 KHz IF, at least in principle. Magne gave the measured 455 KHz image rejection of a typical 525 as 82 dB, while Lichte gave 72 dB. Both are correct. It depends on the frequency at which you measure the 455 KHz image rejection. For my 525, the 580 KHz image rejection of 1490 KHz is about 100 dB, the 1090 KHz image rejection of 2000 KHz is about 90 dB, the 9.090 MHz image rejection of 10.000 MHz is 86 dB, and the 19.090 MHz image rejection of 20.000 MHz is 74 dB. Since signal levels tend to decrease as frequency increases, the 525 decreasing 455 KHz image rejection decreases in the right way. Overall, the 525 455 KHz image rejection is excellent, though not quite as good as the image rejection of an R-390A (455 KHz image rejection in excess of 100 dB at all frequencies, 2-3 MHz variable IF image rejection varies from 76 dB at 20 MHz to 90 dB at 10 MHz, and below 8 MHz all images are down in excess of 100 dB). It is unlikely that I will observe any images on a 525 in an actual listening situation.

The final way that phantom signals can enter a 525 is as intermodulation distortion (IMD) products, both 2nd and 3rd order. When I measured the 3rd order intercept (ICP3) of my 525 at 1100 and 1120 KHz and got -4dBm for the WIDE bandwidth and AM mode, at first I was disappointed. But then I remembered that an R-390A ICP3 is typically -12 dBm, and yet I have never heard any 3rd order IMD products on an R-390A in an actual listening situation. Also, an R8 typically has +5 dBm ICP3, yet 3rd order IMD products are routinely heard on an R8 in actual listening situations (with an antenna connected). For example, I routinely hear the 3rd order product of KWKH 1130 KHz and KRUS 1490KHz at 1850 KHz during the daytime, and numerous 3rd order products of MW signals at night above 1600 KHz on an R8. And in his RDI white paper review of the R8 Magne observed, "... our tests have unearthed intermodulation and cross-modulation products between 0.1 and 3.0 MHz when the R8 is connected to a 160 meter 'super antenna' in an area having strong local mediumwave AM signals." What was going on? The answer was quite simple. ICP3's are measured at 20 KHz tone (signal) spacing unless otherwise stated, yet 3rd order IMD heard on a receiver in an actual listening situation invariably results from much wider spaced signals. When the ICP3's of an R8, R-390A, and NRD-525 were measured at wider tone spacings, a much different picture emerged. For example, with tones at 1130 KHz and 1490 KHz, the 1850 KHz (2x1490 - 1130) ICP3's were +8.5 dBm, +15.5 dBm, and +17 dBm respectively for the R8, 390A, and 525, and the corresponding 3rd order dynamic ranges (DR3's) were 87 dB, 96 dB, and 100 dB respectively. Like the 390A, the 525 has a tuned front end which tracks the received frequency, and they have similar wide spaced ICP3's and DR3's. The R8 with a broadband front end comes in a distant third. This explains why one routinely hears 3rd order IMD products on an R8, but not on an R-390A or NRD-525.

The 5, 10, 20, 40, and 80 KHz spacing ICP3's of my 525 at about 1100 KHz using the WIDE filter and AM mode, with 400 Hz modulated source at 50% modulation were -29 dBm, -13 dBm, -4 dBm, +2 dBm and +2 dBm respectively, At about 9 MHz the ICP3's were -24 dBm, -1 dBm, +2 dBm, +12.5 dBm, and +12.5 dBm respectively. As Denzil Wraight pointed out to me (in personal communications) the close-in ICP3's of an NRD-525 are determined by the 70.455 MHz IF amp and 2nd mixer. The 525 first IF filter at 70.455 MHz typically has a 6 dB bandwidth of about 15 KHz and a 60 dB bandwidth of about 70 KHz. As can be seen from the ICP3 measurements above, when at least one of two strong nearby signals is completely outside the first IF filter passband (more than 35 KHz away from the received signal), the 525 ICP3 is determined almost entirely by the RF amp and first mixer, and is outstanding. And as Denzil has pointed out (in his recent article "More On Modifications For The NRD-525," draft 20193), the 5 KHz spacing ICP3 of a 525 can be improved to about -3 dBm by removing gain from in front of the 2nd mixer and adding it again afterwards, while reducing sensitivity 4 dB. This increases the 5 KHz spacing DR3 by about 8 dB. However, we both agree that there does not seem to be any practical need for such high close-in ICP3's. But if you are determined to try to improve the ICP3's of your NRD-525, you should consult Denzil's article (mentioned above) to learn what has been proposed and works, what has been proposed and doesn't work, and the trade-offs for the mods that work.

Receiver manufacturers seldom specify 2nd order IMD performance. Yet 2nd order IMD products are routinely observed on some receivers in actual listening situations, like on an R8 in the 15.6 - 15.8 MHz range during the early evening hours. These 2nd order products are due to strong SW broadcasters in the 31 and 49 meter bands (e.g., 6.1 + 9.6 = 15.7 MHz). The 15 MHz ICP2's due to 6 and 9 MHz tones were +49 dBm, greater than +64 dBm, and greater than +67 dBm for the R8, 390A, and 525 respectively, and the corresponding DR2's were 84dB, greater than 96.5 dB, and greater than 100 dB respectively. Again, the 525 edged out the 390A, and the R8 finished a distant third. ICP2's and DR2's within the MW band were not as high for any of the receivers. For example, the 1320 KHz DR2's due to 600 and 720 KHz tones were 80 dB, 86 dB, and 91 dB respectively.

"All so called 'specialists' take note: Here at last is a recęiver which is a match to their beloved monster Collins R390A/URR." Thus said Rainer Lichte. It is close, but not quite there. While the 525 edges the 390A in a few important categories like wide dynamic range, the R-390A edges the 525 in other important categories like spurious responses. And the 390A does not generate any display noise which can be received by a nearby MW loop antenna. Were it not for the 525 display noise problem, I would be more inclined to agree with Lichte. But below 1200 KHz the 525 display noise becomes observable above ambient man-made noise at my quiet location, and is very annoying at the low end of the MW band on weaker daytime signals using my 2 foot air core balun loop with amp. At night, however, I haven't noticed any display noise because of greater signal levels, even when using my LIL-4 phasing adapter to combine loop and noise reducing wire antennas for cardioid patterns. So the 525 display noise problem is not as bad as I expected it to be (based on other reports). But I have also heard that the amount of display noise generated by a 525 varies from one 525 to another, so perhaps I have a "tame" 525 in that regard. The 525 display noise is much worse when one uses an amplified ferrite rod MW loop. A ferrite rod loop must be moved further away from a 525 than an air core loop to reduce 525 display noise to an acceptable level. Maybe this accounts for the variation of opinion as to the severity of the 525 display noise problem. Another area where the 390A edges the 525 is AGC performance. The 525 AGC has several annoying characteristics due mainly to inappropriate AM mode attack time constants. Static crashes and noise pulses cause the 525 AGC to "hang," which briefly desensitizes the 525. And at high signal levels the instantaneous fast attack and fast release of the 525 causes low frequency audio distortion on AM signals. Fortunately, these 525 AGC defects can be greatly reduced as described in my article, "NRD-525 AM AGC Mod 2," by replacing R104 with a 220K ohm surface mount resistor, adding a 22K 1/4 watt resistor from pin 2 of IC7 to pin 4 of IC8, and adding a jumper from pin 3 of IC8 to pin 3 of IC9. This mod greatly increases the AM mode attack time constant, which eliminates AM audio distortion due to audio on the AGC line, and greatly reduces AGC "hanging" due to static crashes and noise pulses in AM mode. Also, my 525 does not extract as much signal from my noise reducing vertical antenna at the low frequency end of the MW band as a 390A. The difference is about 6 dB. Perhaps it is due to the reflected capacitance of the zip cord twin-lead detuning the 525 front end. The 525 does not have an antenna trimmer, which would help in analyzing and eliminating problems like this. However, I have not yet heard a signal at the low end of the MW band on a 390A that was not equally audible on a 525. Curiously, a 525 overloads when signals greater than about 50,000 microvolts are applied to the antenna input. This is unlikely to be a problem for most 525 users unless they use antennas which develop excessive signal levels, or have extremely high RF environments. Overload appears to occur first at the 2nd mixer, but the 1st, 2nd, and 3rd 455 KHz IF amps may also be involved. At present I do not have a soultion for the overload. Finally, although I haven't found it much of a problem, many people have complained about the 525 digital S-meter jumping around all over the place. I do agree, however, that an analog S-meter would be an improvement.

Of course, an NRD-525 has a number of advantages over an R-390A: it can be carried around the house easily and on DXpeditions, it can be powered from two 6 volt lantern batteries, you can jump from one frequency to another much quicker, you have available 200 programmable memories which permit even faster frequency jumping, and you don't have to fix it yourself if something goes wrong with it.

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