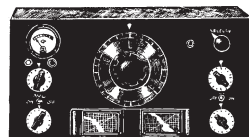


THE COMMUNICATIONS RECEIVER



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The National HRO-500

This column will be the first to cover a solid state receiver. The design of the HRO-500 is quite different than that of the preceding HROs. However, though National broke with the traditional design in some ways, the method of construction reminds us of the older receivers.



The HRO-500 with accessory LF-10 preselector.

This radio weighs 32 pounds, about like the early HROs. Though it is solid state, the wiring is all point-to-point and, like the vacuum tubes in prior receivers, the transistors are socketed. The dial is a modification of the old epicyclic HRO dial, now incorporating a ball-bearing vernier that gives two speed tuning, quoted as 10 or 50 kHz per dial rotation.

Each of the 500 dial divisions now cover 1 kHz, so there's no need for the graphs or charts used on the older HROs. This new receiver covers 30 MHz in sixty 500 kHz bands, eliminating the need for plug-in coils. The design includes a phase locked loop with output each 500 kHz. The output is mixed with the analog VFO for signal

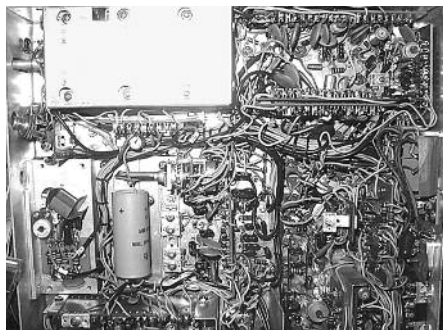
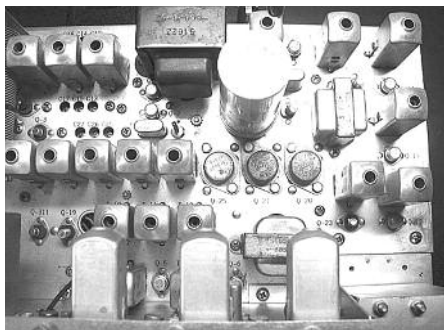
conversion to the IF strip, a system that was used by much amateur gear for the next 20 years.

The frequency readout was given by a drum which is connected to the selector system, which tunes to a harmonic of the 500 kHz crystal oscillator. This number added to the VFO reading gave the signal frequency. The drum is connected to the system which selects the harmonic of the crystal oscillator. The phase locked loop is then locked to the selected oscillator harmonic.

The IF strip is set to 262 kHz. Six "Cup Core" tuned transformers are used to produce selectivity in 4 steps, from 500 Hertz at 6 db down to 8 kHz at 6 db down. This goes to either a product detector or a diode detector and an audio amplifier capable of 2 watts output. Power is generated from an internal AC to DC supply, operable from 115 or 230 volts, or an external 12-volt battery pack can be connected to the back panel.

Most of us will remember the ads produced by the National Company for the HRO-500. These started in late 1963, and described a receiver that was "too good to be true" at the time of 75A-4, NC-300, SX-101 and SP-600, or even the new lightweight Collins tube type S-Line receivers. Highlights included in the National brochure include the following:

- Complete coverage of the entire VLF/HF spectrum between five kilohertz and 30 MHz, with the same superb dial calibration, stability, and tuning rate throughout.



Top and bottom views of the HRO-500 chassis.

- Total transistorization for maximum reliability and versatility with minimum heat generation and power requirements.

- MTBF per NAV-SHIPS 93820 of 3820 hours results from conservative circuit design and proper de-rating of all components.

- Operates (with no need for accessory supplies) from 117/234 V.A.C. or 11-16 V.D.C. sources. Current drain at 12.6 V.D.C. is only 200 mA.

- Complete SSB, AM, MCW, and CW facilities, including both product and diode detectors; passband tuning of filter for true selectable sideband reception; fast attack, slow decay AGC; and four discrete bandwidths from 500 Hz to 8 kHz.

- Dial calibration accurate to one kilohertz over the entire frequency range, with bandspread of $\frac{1}{4}$ " per kilohertz and 24 feet per megahertz.

- Selectable tuning ratio of either 10 kHz or 50 kHz per revolution of main tuning control for choice of rapid band-scanning or fine tuning at will.

- "Instant-on" operation with no warm-up period required.

- Superb short- and long-term stability. Nominal stability, including 7% change in AC input voltage, is better than 100 Hz per day and 50 Hz per degree C.

- Frequency determination by mean of phase-locked crystal frequency synthesizer assures maximum stability and elimination of band-to-band recalibration.

- Sensitivity and image rejection (averages 80 dB, minimum 50 dB) superior to the previous standard of comparison—the earlier HRO receivers.

- Unusually flat audio response—100 Hz to 5500 Hz within 6 db, with over 2 watts of available audio output.

- Complete remote control provisions including AF and RF gain, BFO on-off, receiver mute, and power on-off.

- All necessary oscillator, AGC, IF and detector outputs provided for use with accessory equipment.

This was a lab grade receiver that covered from 0 to 30 MHz without the external coil packs that were a hallmark of the earlier HROs. It could be powered by flashlight batteries, and the pilot lights required as much energy as the rest of the receiver. Best of all it had the silky smooth dial reminiscent of the original HRO with the new built-in vernier giving about a 5-to-1 ratio (also stated at 3-to-1 in the National literature). Thus it could be tuned at slow speed for CW and SSB with the inner dial, and faster for AM, or quick band excursions, with the outer dial.

In cold hindsight, this receiver had problems that have made it more of a cult receiver than a recognized technological milestone. Transistors used in the design included both germanium and silicon units. The ability to handle strong signals was not very good with these early transistors and the architecture of that time. With age, component value drift would cause the phase lock loop to lose lock on some ranges, or parts of some ranges. The audio quality of the HRO-500 was not very good, and the 6 pole cup-core 262 kHz IF filter did not have the excellent shape factor that was being achieved with the mechanical or

crystal lattice filters which were available at that time.

Depending on your level of dedication, some of these shortcomings can be overcome. Once the initial component drift had stabilized, an alignment would return the phase lock loop to proper operation which would then be stable for quite a long time as long as the receiver was not exposed to a large temperature variations or shock. The audio system shortcomings could be corrected, and several articles have been written on how to perform these improvements.

There was an article in the *ARRL Handbook* of about 1978 that described a system to add variable selectivity to an older receiver, particularly those units with an IF that was not at 455 kHz, which was typical for the mechanical filters and many of the crystal filters of that era. This system converted the IF signal to 455 kHz, passed it through a 455 kHz filter, then converted it back to the original frequency. By using a variable conversion frequency you could offset the filters, reducing the bandwidth.

This system was built in and widely used in subsequent communications gear. The problem with handling of strong signals could be improved with a switchable RF attenuator. Dynamic range will not be very high, but overload would be improved.

These receivers were widely used by various agencies and companies as test equipment as well as for monitoring and other communications receiver applications. One of the ads which caused us to drool showed an NCX-5 setup with the HRO-500, station accessories and NCL-2000 amplifier as the perfect amateur station, in a yacht, or in a home. There were even a set of walnut cabinets available for the gear.

The first of these receivers that I worked with had been used by Tropical Radio and Telegraph at station WNU, Pearl River, Louisiana. TRT had been in business from the 1920s and possible earlier. I have seen an article stating that WNU was converting from long wave to short wave in the early 1920s. WNU was primarily involved in communications with the "banana boats" traversing the Gulf of Mexico. The primary

communication mode was CW.

Typically the frequency range used in this service was limited, so these receivers operated on only a couple of bands for 24 hours a day, seven days a week. Maintenance needed only make sure that they operated on those particular bands. In addition the operators were typically heavy smokers, so all the contacts that were not normally used for CW operation were covered with tar.

These sets had been in use until they were obsolescent, then as they failed they were put in storage. Typically the physical condition was only fair to poor. There were spots of corrosion on the heavy die cast front panel, the paint was discolored from exposure to cigarette smoke, and many of the aluminum knob inserts were discolored, corroded, or missing.

I found that polishing the front panel to remove corrosion would also remove the anodized finish; this was replaced by a clear spray-on plastic coating. The coating might not be as durable as the original, but the anodized parts do not normally see any wear. Cleaning of the chassis on these receivers was time consuming and quite frustrating. Accessibility is poor due to the synthesizer and tuning systems being built inside boxes mounted above the chassis.

To make matters worse, the transistors are socketed. In order to do a good job you really need to remove all the transistors, carefully noting the orientation and the socket for each transistor. Variable characteristics of these transistors meant that exchanging two units of the same type might change the alignment and stop a working receiver from operating properly.

The knob inserts are .100" thick aluminum, the normal ones are 1" in diameter. There are smaller ones, however, as well as a large one for the tuning knob. You can turn replacements on a lathe to replace the originals. I used a much finer feed to wind up with shiny inserts as opposed to the originals, which look like they used a .020" feed rate. Once parted off, I cleaned up the spur on the back with a Dremel tool and coated these inserts with the clear plastic spray-on finish.

The transistor sockets also have to be

cleaned with a contact enhancer. A small toothpick can help in this task. Transistor leads should also have this material applied. On one of the units, the failure was caused by the freezing of the variable capacitor that selected the harmonic of the oscillator. When the operator had tried to change frequency, the dial string was broken.

Once the clean-up was finished and the dial string replaced and all contacts on switches and variable resistors had been treated, this receiver would work on a few bands. All of the front panel controls were operational, and performance was about as expected.

Then came the task of getting the phase lock loop to work on all bands, and insuring that the band selected was the one actually tuned. It is possible to align the PLL so that the frequencies do not match the dial indicators. The signals are available at the back panel, so alignment is not particularly difficult, but it is very time consuming since there are 60 different bands for the receiver. You can also align the VFO at this point. The VFOs are not very uniform, some track very well from end to end, and others are off by several kHz at points in the 500 kHz range.

We should note that one version of the HRO-500, the HRO-500P, was made for portable use. This variant included an internal speaker, rechargeable Ni-Cad batteries, and had a carrying case available. For the standard table version there were available: a rack mount adapter, external speaker, and the LF-10 low frequency tuning system to improve sensitivity in the 0-500 kHz range.

This accessory also could be fitted with plug in audio filters.

Some of the main tuning knobs have a spinner attached and some do not. The receivers were produced in several series, the first series was designated by the numbers 77 preceding the serial number. These do not include quite a few changes which were made prior to the 88 series production. The serial number and series were ink stamped on the back of the chassis, visible from the rear. Cleaning could easily remove this ink.

Due to the high cost, production of these receivers was limited. It appears that production ran for about five years, from late 1963 through 1968. Use of these receivers is varied today. Many collectors feel that they must have one, but the drawbacks are such that they are not used. On the other hand there is a devoted group of owners who use these receivers daily. Compared to modern gear they are relatively fragile and do not like vibration, high humidity, or large temperature changes. The germanium transistors are difficult to find, but unlike vacuum tubes, a good one will last a very long time. With care, your great-grandchildren will be able to use your receiver.

In case you have one of these receivers that is not working properly, it can be repaired. However bench time for repairs will be high; they are not easy to work on. Adjustment of the PLL lock points can be frustrating. Sales prices of used HRO-500s in working condition have continued to increase. \$1,000 for one in good condition is a real bargain in today's market. 

HI-FI, continued from page 29

that encases both conductors. Although this cable originally came with the kit, I suspect there were many kit builders, like me, who didn't bother with the loop. My original cable for a loop was long gone, of course, but the Shack has a good substitute (RS type CL2).

I had used the tuner only with a long-wire antenna before, but decided this time I had to try the loop. I'm glad I did. With the

long-wire antenna the tuner received 20 stations, but with the loop substituted for the long-wire it received 31 stations. How this is possible with a loop of shielded wire is beyond me. Are there any antenna theorists out there who could elucidate?

And do you suppose I can get one more re-excitement over this hi-fi in my lifetime? 