A Custom MW DX Receiver

by Ray Moore

It seems that my life has been a continuous search for the "ultimate receiver". My focus has been very narrow; I'm interested only in foreign MW reception from a fixed location, and I've been designing and building receiver circuits to fulfill this aim for a number of years.

My present receiver started in 1968 as a copy of the R-390A circuitry pertinent to MW reception and used 17 tubes and 2 FETs. Ham Radio magazine ran an article on this receiver in June 1974, and The NRC Receiver Manual contains an article, "Receiver Hot-Rodding Hints", which covers some of the design philosophy behind the receiver. Since then, the set has gradually evolved to the present all solid state set with 10 diodes, three bipolar transistors, five JFETs, five MOSFETs and three ICs. Only the National PW
dial and variable capacitor assembly (as used in the National HRO) and the cabinet remain from the original unit. See Figure 1, "Receiver Fact Sheet" for the most recent block diagram of the radio.

As in Nick Hall-Patch's receiver (described in DXM October 20/27 and November 3, 1990), almost all circuits are modularized, being built into Hammond die-cast aluminum boxes. Above the receiver chassis are four boxes containing the Q-multiplier (QM), second IF filter (FL2), HFO/buffer and the mixer, while below chassis, there is a power line filter, first IF filter (FL1), the four IF amplifiers, as well as the detector and AF amplifier. All circuitry is built using the "ugly" technique, in which all components are supported upon a copper PC board by the circuit ground plane connections. I'm convinced that this is the ultimate construction technique for performance and efficiency. I usually build the input circuitry on one side of the PC board, and the output on the other.

The original circuit used a 7360 beam deflection vacuum tube as a balanced mixer which provided strong signal handling capability. The present 40763 MOSFET mixer circuit is properly optimized and does a better job than its predecessor. I had several Mini-Circuits Laboratories SRA-H double balanced mixers on hand and had planned to eventually use that circuit, but I have not had any signal handling problems with the optimized MOSFET circuit even when I lived in the Boston area. In recent years, I've only used loop antennas, which greatly reduce the potential for strong signal handling problems.

Of course, I do use some preselection between the antenna and the mixer. The mixer input tuned circuit uses a Miller A5495A antenna coil with a high impedance (10 kilohm), loosely coupled primary, so that the secondary is lightly loaded and tunes very sharply. Although the receiver is normally used with just this input coil, there is an additional separately tuned preselector (also a Miller A5495A) which acts as a Z match between the antenna and the high impedance of the antenna coil. This results in a sensitivity that is good enough so that external noise is the limiting factor in reception. The preamplifier is primarily used for increasing the receiver's sensitivity when listening with low gain loops; it uses a CP640 power FET and has a 3rd order intercept point of +40 dBm.

The Hartley high frequency oscillator (HFO) is really stable and uses a toroidal core for its inductor, along with N750 ceramic capacitors for temperature compensation. The 2N2222 buffer provides an optimum 6.5 V peak to peak injection to the mixer. The other HFO buffer drives a Ramsey CT-50 counter with a receive adaptor for frequency display.

The mixer feeds a Kokusai 2.4 kHz wide 455 kHz filter. Although there are four stages of IF amplification, I prefer manual gain for DX listening, so there is no AGC. There are two IF gain controls which are used to optimize circuit gain before and after an IF noise limiter placed halfway through the IF strip. This noise limiter is made up of a pair of Hewlett-Packard hot-carrier diodes (I have used the germanium 1N270/1N277 diodes with similar results) shunted directly across a shunt fed IF transformer. The clipping level is established by the relative settings of IF Gain 1 and IF Gain 2. Once the proper level is found, both IF Gain 2 and AF gain are left fixed, and IF Gain 1 is used as the primary gain control. Unlike audio noise limiters, the system introduces no distortion when the clipping level is properly set. It is especially effective in limiting speech splatter from adjacent transmitters, often reducing it to nearly nothing without affecting the desired signal. The limiter is usually switched off only to allow comparisons.

An aside here: some users of regenerative loop antennas, such as the Martens and KIWA, rave over their ability to isolate and peak weak DX signals, attributing it to the increased selectivity provided by the loop regeneration. However, these users are experiencing exalted carrier reception, first proposed by Villard in 1952 and used for serious DXing by Gordon Nelson in the 1960's.

Here is how it works (refer to Figure 2): Curve A is the selectivity of a typical loop antenna at 740 kHz with a Q multiplication factor of 20, which is easily obtained with regeneration. This curve is superimposed on the IF selectivity curve of your receiver, Curve B. The resultant selectivity curve is the shaded portion of Figure 2. Place the carrier of the desired signal in the center of the peak of the curve and the carrier is "exalted" by 20 dB relative to the upper sideband in this example.

This technique is much better implemented at the receiver intermediate frequency as described in some detail in my article in DX News and in the NRC Receiver Reference Manual. Briefly, the exalted carrier peak should be produced as far along the IF chain as possible to protect the regenerative amplifier from off-frequency signals, and to protect it from noise peaks using the above described noise limiter. My receiver uses a Q-multiplier (QM) circuit for the regenerative amplifier, and two peaks can be selected by a USB/LSB switch. Operation consists of selecting either USB or LSB and then tuning the receiver to place the desired carrier in the center of the peak. Unlike the regenerative loops, there's no knob twiddling here.

The Q-multiplier "carrier exaltation" actually attenuates everything but the carrier, so audio frequencies above about 900 Hz are suppressed in the demodulated signal. A high-pass audio filter helps to restore these frequencies, but a fair amount of audio gain is required to compensate for the reduced audio. It is important that both the QM and the HFO are stable, as the QM must be tuned to within 10 or 20 Hz of the desired signal's carrier. I use a toroidal inductor in the QM, similar to that used in the HFO, to provide this stability. As the tuning is tight, a varactor RIT control is very useful.

Overall, I believe that using the Q-multiplier is far superior to the phase locked carrier method for serious DX work, as there are no problems with trying to lock on a carrier in the noise or next to a strong signal. In addition, exalted carrier reception is a quite different technique from the use of the BFO for carrier replacement which is available on many of the better commercial communication receivers. I have compared my method with the BFO method on many receivers and found that there is no comparison in clarity and "presence" on weak signals. The advantage of the QM is that it works best when other techniques are at their worst---when weak signals are in the noise and covered by interference.

The receiver does not have a notch filter. With the cascaded mechanical filters plus a Q-multiplier, there are no heterodynes when the receiver is properly tuned. There is also no S-meter; without AGC, I prefer to peak the receiver tuning on noise or weak signals.

After years of almost daily tinkering with my home built receiver, I seem to have reached a point where I don't know of anything I would change in it right now. I still use it, but haven't had it out of its case for several years.

REFERENCES

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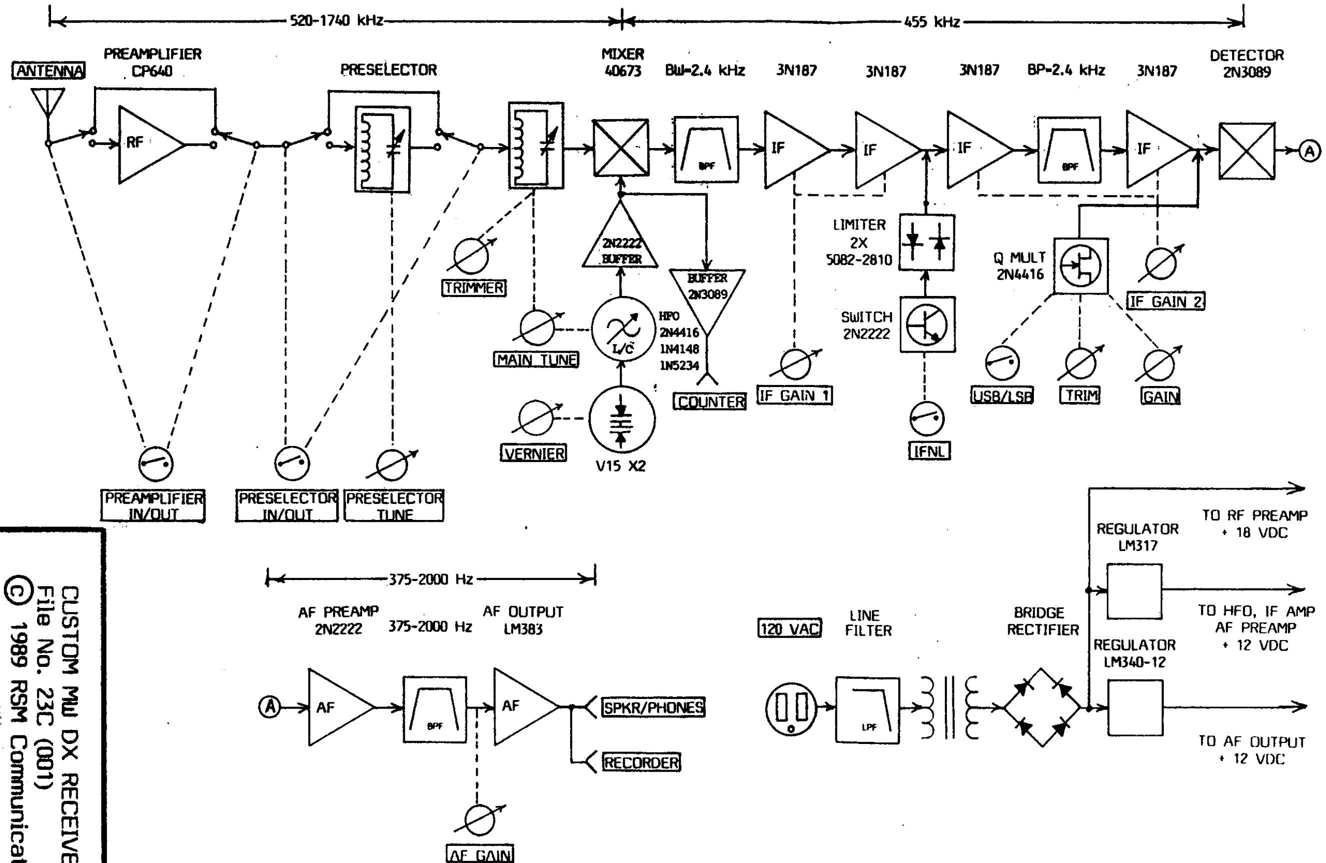
RECEIVER FACT SHEET



CUSTOM MW DX RECEIVER
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Figure 1

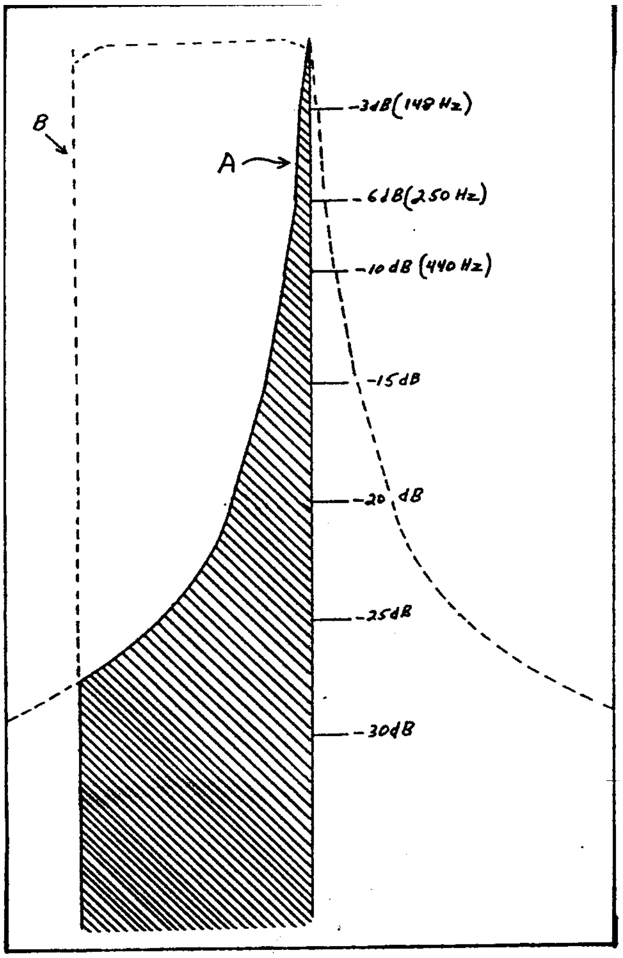

Figure 2 - Selectivity curves of a regenerative amplifier (A) and a typical IF bandpass filter (B) superimposed on each other. The resultant selectivity curve is the shaded area.