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Quantum Loop Test Evaluation and Improvements
Mark Connelly - WA1ION - 30 APR 1992

I recently purchased a Quantum Loop from its designer, Gerry Thomas. I ran it through a full gauntlet of tests (sensitivity, strong-signal handling, nulling ease, and sharpness of tuning). Receivers used included R-390A, Kenwood R-600, Realistic DX-440, and Sony ICF-2010. Oscilloscope testing was also performed.

The loop, as advertised, delivers a healthy signal level for the small ferrite head used. Q (selectivity, tuning sharpness) is excellent. To see how much sensitivity could be attributed directly to the loophead, the Quantum head and the Palomar MW head were compared by plugging each into my RTL-1 Remotely-Tuned Loop amplifier box assembly. Gerry's Quantum head, on average, delivered about 3 dB more signal than did the Palomar head. That's certainly not much in most listening situations, but it can make the difference on low-level signals (e. g. during the day) at electrically-quiet locations. The amplifier in the Quantum Loop delivers substantial gain. Its gain is comparable to that of the updated RTL-1 loop using Dallas Lankford's balanced amplifier (BFE-C of my designation) followed by the extra 20 dB kick of my BBA-C broadband amplifier. Such gain is indeed required with small ferrite loop heads. The Quantum and the RTL-1 both have much more gain than the Palomar and Radio West loops. The remotely-tuned RTL-1 needs +12 VDC at about 120 mA and a control box / control cable assembly. The Quantum, like most loops, is meant to be co-located with the receiver. Its simplicity, small size, and 9-volt battery operation makes it ideal for many travel applications (as long as a suitably low-noise, non-shielded operating environment is available). If you're thinking of getting a Palomar primarily for medium wave use, forget it. Get the Quantum instead.

Keeping amp. noise under control with such high gain is not a trivial matter. Both Gerry's Quantum amplifier and the BFE-C/BBA-C combination of RTL-1 achieve this task. The Space Magnet and the Palomar are inferior in this regard.

Nulling with the Quantum Loop was about as good as nulling with the Palomar (and better than nulling with a Space Magnet or Radio West loop).

<u>A few "bugs" in the Quantum Loop</u>

* Just before sunset, a RTTY spur - obviously a shortwave mixing product - was noted around 1207 kHz. As Dallas Lankford and I have both noticed, mid- to late-afternoon, when MW is still essentially non-skip but lower SW band skip has built up to strong levels, is the worst time for such spurs. The problem, as noted later in this article, was easily solved.

* Harmonic distortion was obvious in the presence of WRKO-680 showing up on 1360 if the loop tuning wasn't precisely on 1360. Weak, remnant WRKO audio could be heard behind WLYN-1360 even with the loop properly peaked. Surprisingly, reducing the loop's gain did not reduce the harmonic (WRKO) relative to the true 1360 signal (WLYN). The problem <u>was</u> largely mitigated by modifications to be described below. (WRKO runs 50 kW from a transmitter site approximately 3 miles / 5 km from my house.)

* As Gerry has also noted, oscillation is possible if the loop is operated into a poorly-shielded (plastic-cased) receiver such as a Sony ICF-2010. Palliatives for this are to increase the distance between receiver and loop, re-orient the receiver and/or loophead, reduce the loop gain setting, and reduce the receiver's RF gain setting.

<u>"Spraying the bugs"</u>

Scope tests showed that the gain pot implementation was flawed. Local WRKO-680 was peaked up and observed on the scope with a 50-ohm BNC terminator installed (to simulate a receiver). The waveform was severely distorted (clipped) at about 0.8 Vp-p. I presumed that the gain pot would remedy this and allow a lower level undistorted signal to be obtained. Wrong! Reducing the gain setting did, of course, reduce the signal level -- but waveform distortion got worse ! What I was observing on the oscilloscope in the time domain would equate to greater harmonic content (e. g. 1360, 2040) in the frequency domain. The gain pot scheme was investigated further. As the lowest strong-signal distortion actually occurred at maximum gain (R7 set to zero ohms), I removed that pot and connected the end of R9 (that had gone to R7) directly to ground. Experimentation showed that a 5K audio-taper pot (to ground) connected through a 0.1 uF capacitor to the C4/R8 junction performed gain control that (a) provided gain control that did not increase distortion, and (b) provided a greater range of gain control than the previous scheme did.

I also wondered whether the output impedance of the loop amplifier gave a good match to a 50-ohm receiver input. I tried several "canned" Mini-Circuits RF transformers (2:1, 4:1, 9:1, 16:1, and 36:1) between the output of the Quantum Loop and the R-600's 50-ohm input. The 16:1 transformer (T16-6T) did the best job: signal transfer was at least 5 dB better than with a direct connection. Tests with the oscilloscope (with 50-ohm terminator) showed the same improvement. Furthermore, harmonic distortion on "cruncher" locals like WRKO-680, WHDH-850, and WSSH-1510 was reduced: more output <u>and</u> less distortion with the 16:1 transformer in line. These tests indicate that the output impedance of the Quantum Loop is in the 500 to 800 ohm

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range - hardly a good match to the vast majority of modern receivers which want to "see" 50 to 75 ohms. The addition of a T16-6T or T16-1 transformer at the loop's RF output should be considered mandatory for best performance. No doubt the 12:1 homebrew toroidal transformer described by Nick Hall-Patch's Beverage-matching article in Proceedings would also work well. When observing WRKO-680 on the oscilloscope, the Quantum Loop with T16-6T transformer delivers about 3.5 Vp-p (clipped) into the 50-ohm terminator and, if the loop is rotated a bit off the peak-strength position, 2 Vp-p of relatively undistorted sinewave can be obtained. Somewhat greater undistorted output levels can be attained if the DC input is changed from +9 VDC to +12 VDC. Studies of RF amplifiers here show that passing a single large-signal frequency with low distortion usually also means that multiple frequencies can be passed with less likelihood of mixing spurs (intermodulation distortion products). These concerns are of paramount importance to the urban DXer.

The RTTY spur was cured by the addition of 47 uH inductors between VC1/L1/switched C1 and the R1/Q1 gate junction and between VC1/L1/C1 and the R2/Q2 gate junction. Some circuit board trace cuts were necessary. This modification was inspired by similar shortwave-spur fixes done by Dallas Lankford.

Other minor modifications were performed. A phono jack (J5) was added near the existing J4 power input. I did this because I have several AC adapters fitted with phono plug outputs to interface to much of my homebrew gear. A 10 ohm resistor (R13) was added in series with the DC power input. This forms a low-pass filter with capacitors C7 & C10 to do a better job removing noise spikes, stray RF, and switching supply transients from the power buss.

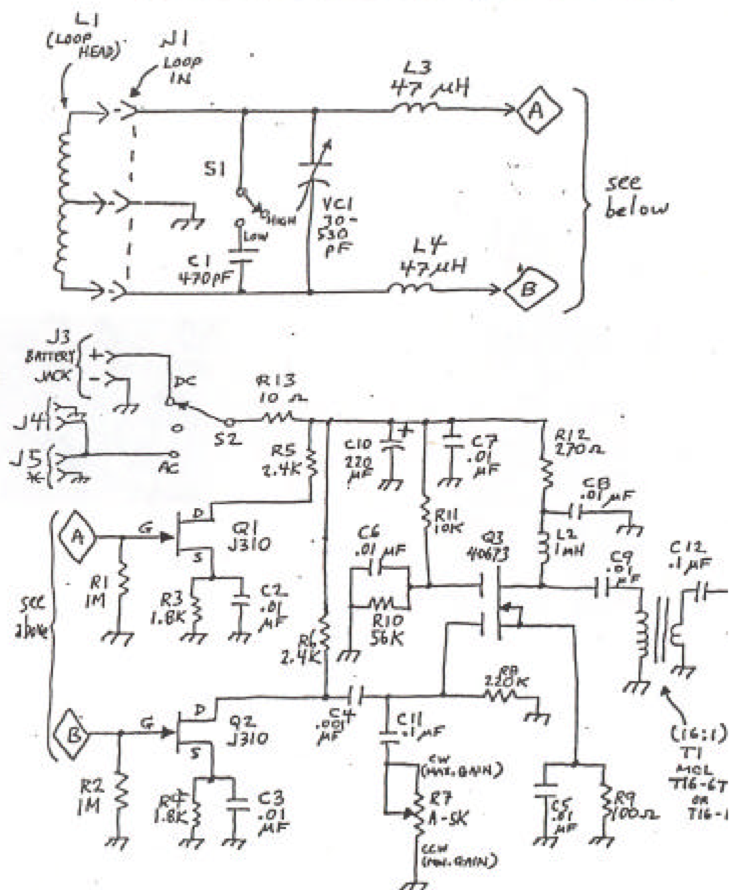
Conclusions

The Quantum Loop, with the modifications described above and in Figure 1, is the best small 9-volt-powerable medium wave loop I've ever used. It is perfect for travelling when used with a Sony ICF-2010, Realistic DX-440, or similar receiver.

Phasing Applications

All that has to be done to make this loop phasing-compatible is to add a toggle switch in series with a 20K resistor. By switching in the resistor across the tuning capacitor, Q can be reduced to provide adequate null bandwidth for phasing applications. The gain pot can be used for level-equalization operations.

FIGURE 1: IMPROVED QUANTUM LOOP



*= ADDED PHONO JACK (SEE TEXT)