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WHAT'S WRONG WITH PRESENT DAY LOOP ANTENNAS

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The purpose of this article is to discuss what's wrong with present day loop antennas, and to suggest some solutions for those problems.

There are often several reasons why a given loop antenna does not perform well, but the most frequent problem for amplified loops is excessive amplifier gain. I don't know why so many DXers believe that more gain is better. Excessive signal input to a receiver has only one effect, and that is bad - the dynamic range of the receiving system is degraded. Also, high gain amplifiers frequently have poor dynamic range; they are often the cause of spurious responses such as intermodulation distortion products and cross modulation.

When Gordon Nelson introduced his 4 foot square, balanced, tiltable, amplified, air core loop in the 1960's, it was not optimized for strong signal handling performance. This should not be taken as a criticism of his pioneering work. After all, concepts like dynamic range and 3rd order intercept had not yet been defined, and DXers were generally not familiar with the negative effects of excessively high signals.

A 4 foot square loop is too large. Most DXers do not have room for such a large loop, and it is not easy to construct a 4 foot square loop which is mechanically stable. The amp Nelson used also has too much gain. Nelson himself mentioned cross modulation problems with his loop and amp. Other DXers developed scaled down versions of his loop, but excessive amp gain has remained a common problem.

The first balanced, tiltable, air core loop I built was 2 feet square, inspired mainly by Russell Edmunds' NRC loop and Ralph Sanserino's loop (IRCA reprint A8). It is still my main air core loop antenna. However, the first amp I built was long ago tossed in the circular file. Subsequently, I must have built just about every loop amp ever published. They all had too much gain for a 2 foot air core loop, and they all suffered from spurious responses and other problems related to excessive signal levels.

Perhaps it is appropriate to remark here that no single loop antenna is optimal for all receivers and all locations. For some receivers, like the HQ-180(A), an unamplified, 2 foot, air core loop is sufficient. For others, like the R-390A, 51J-4, and HQ-150, a low gain amp is needed for adequate signal levels with a 2 foot, air core loop. And for some recent solid state receivers with desensitized MW bands, still more gain is required. In addition, the minimum ambient background noise is an important factor in determining how much loop amp gain is needed. For example, a DXer in a large urban area will usually have higher power line and other man-made noise than a DXer in a small town or rural location. Consequently, a less than optimal loop antenna is generally satisfactory for an urban DXer.

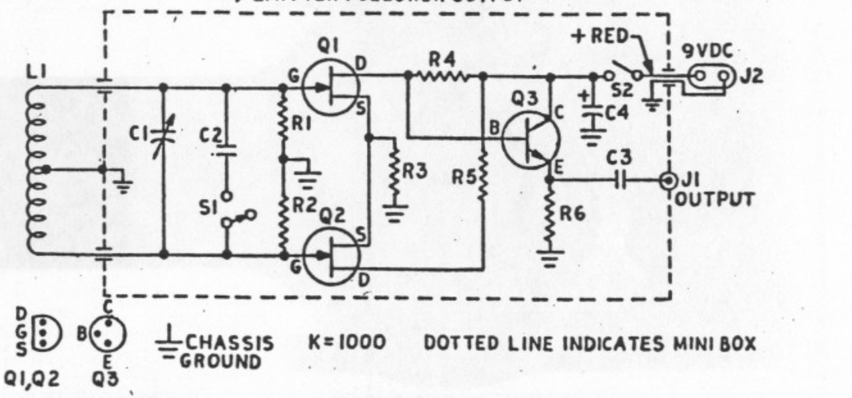
It doesn't make any sense to use a high performance loop antenna for MW DXing unless you use it with a high performance MW receiver. So the following discussion about loop antennas is concerned mainly with loop antennas for use with an R-390A, 51J-4, HQ-180(A), or HQ-150. The loop antennas I will describe may also work well with other receivers, but I make no claims in that regard. Many recent top of the line solid state receivers, such as the R-71A, R-5000, and NRD-525, are either insensitive throughout the MW band (they are deliberately designed that way), or emit digital display noise in the MW band, or both. I have been told that it is possible to use one of these MW RFI emitters with a loop antenna by separating the receiver and loop antenna, but I cannot guarantee that.

If you aren't inclined to build a rather large and complicated air core loop antenna, there is a much easier way to get a small and very good loop antenna. Buy the Radio West "Great Little Loop" and modify the amp for reduced gain. This loop has been around in various forms for many years, and is built by Ralph Sanserino. The amp used in these loops is a balanced differential amp which Ralph told me he obtained from John Kolb in late 1970 or early 1971; see Figure 1 below.

I first saw this amp about 1980 in IRCA reprint A8, a description of a balanced, tiltable, amplified, 2 foot square, air core loop written by Ralph. A few years later I tried the amp with my 2 foot air core loop, but like all the other amps I tried, it had way-too much gain for a 2 foot air core loop. Through correspondence with Paul Kowalski I learned that the same amp was used with Ralph's ferrite rod loops, so eventually I tried it with some ferrite rod loops I prototyped. The amp gain was too much even for the lower signal levels developed by the ferrite rod loop coil. However, I recently discovered that amp gain can be reduced by reducing the values of the load resistors R4 and R5. With lower gain the overall performance was much better — less amp noise, fewer and weaker spurious responses, clearer split reception, and so on.

FIGURE 1

DIFFERENTIAL BALANCED PREAMP W/EMITTER FOLLOWER OUTPUT



C1-365PF VAR CAP.
C2-330PF CAP.
C3-.01 UF CAP.
J1-PHONO JACK
J2-9 volt BATT SNAP
L1-10 TURN LOOP
C4-100UF 15V CAP.

Q1,Q2-2N3819 FET, MATCHED
Q3-2N3646 NPN
R1,R2-100K OPTIONAL-NOT REQD
R3-1K
R4,R5-4.7K
R6-2.2K
S1,S2-SPST SWITCH

After considerable listening tests with different values for R4 and R5, the optimal value of R4 and R5 was found to be about 470 ohms for the following three types of ferrite rod configurations; see Figure 2 below. One loop consisted of a four rod bundle with two rods end to endand the other two rods stacked in the middle. The rods were 8" long, 3/8" diameter, 125 permeability. The 4 rod bundle was wound with 24 turns of Teflon insulated #22 tinned stranded wire, center tapped, close spaced, at the center of the bundle. A second loop consisted of seven rods of the same kind, bundled together without overlapping, and had a 26 turn coil. A third loop used a Space Magnet rod which is 12" long by 9/16" diameter, 400 permeability. The coil was 30 turns. Signal levels with all three loops was about the same. A smaller single rod or fewer bundled rods are not recommended because sensitivity of the antenna would be reduced.

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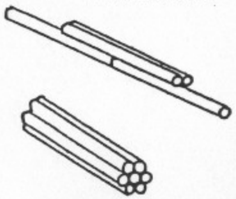
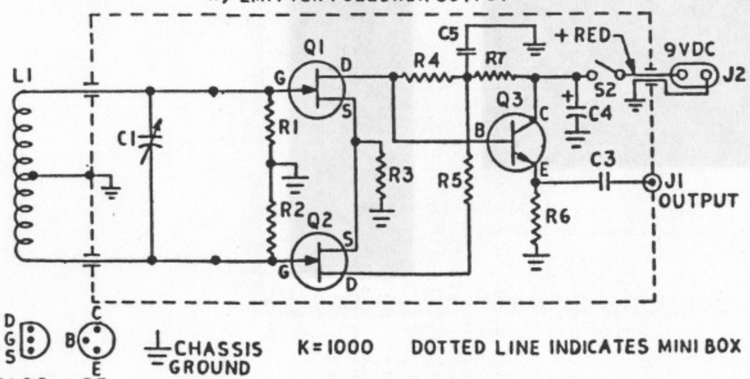


FIGURE 2

After discovering how to reduce the gain of the amp, I turned my attention to the remaining two problems with this amp -- amp noise, and spurious responses. With the original 4.7 K load resistors, amp noise was quite obvious as 10 dB or more carrier meter indication on an R-390A with the receiver tuned to an empty spot above or below the MW band and the loop detuned to the opposite end of the MW band. Some improvement in amp noise was obtained by hand selecting Q1 for minimum noise, but 3 or 4 dB noise remained despite my best efforts. Spurious responses were minimized by "matching" Q1 and Q2 in the sense that they were hand selected for nearly as possible (within 2 %) equal drain voltages. However, some spurious responses remained. The remaining spurious responses were found to be 2nd order IMD products, and were generated by both pairs of MW signals and pairs of SW signals. Not entirely by accident (while testing a differential amp designed and developed in UK by Trevor Brook and Dave Porter) I discovered that amp noise could be further reduced (to 0 meter indication on an R-390A) by changing the FET load circuit, and that spurious responses could be further reduced by increasing the source resistor R3 from 1 K to 4.7 K. My final circuit is shown in Figure 3 below.

FIGURE 3

IMPROVED
DIFFERENTIAL BALANCED
PREAMP
W/EMITTER FOLLOWER OUTPUT



C1- 660 PF VAR CAP. straight line freq.
C5, C3-.01 UF CAP.
J1- PHONO JACK, BNC, or SO239
J2-9 volt BATT SNAP
L1-10 TURN LOOP
C4-100UF 15V CAP.

Q1,Q2-2N3819 FET, MATCHED
Q3-2N2222A
R1,R2-100K
R3-4.7K
R4,R5- SEE TEXT
R6-2.2K
R7- 4.7 K
S1,S2-SPST SWITCH

In addition to the load circuit and source resistor changes, you will observe several other changes from the original circuit. First, the two band tuning via switched C2 has been replaced with single band tuning by deleting C2 and replacing C1 with a 660 pF air variable. I have also specified the main tuning capacitor C1 as straight line frequency. Second, the 100 K gate resistors R1 and R2 are not optional for this circuit. Without the gate resistors R1 and R2 the Q of the tuned circuit is considerably higher, so high that signals may be distorted unless they are tuned precisely. With R1 and R2 the Q is lowered and audio quality is improved. Also, the lower Q reduces amp gain by maybe 4 to 6 dB, which lowers 2nd order IMD products by about 8 to 12 dB.

As before, resistors R4 and R5 are the load resistors, and they determine the gain of the amp. The maximum gain of the amp occurs when R4 and R5 are about 2.2 K, so there is no point in using larger resistors. Maximum gain should be used with the ferrite rod loops discussed above. I have also used the amp with a one foot air core loop, 20 turns, 1/4" spacing between turns. In that case the load resistors R4 and R5 should be 470 ohms. However, I do not recommend using the amp with a one foot air core loop because weak 2nd order IMD products were observed at the threshold of detectability on nights with strong signals (loop tuned to my super local, and R-390A tuned through the 480 - 520 KHz range with the BFO on). The only amplified air core loop I have used which is completely free of IMD products is my 2 foot air core loop with high dynamic range balun amp. I will discuss a 2 foot air core loop, baluns, and a high dynamic range amp in a future article.

With a 660 pF air variable capacitor the tuning range can be adjusted for at least 500 KHz to 2000 KHz. This is more than is needed for tuning the MW band, even with the upcoming frequency changes. So a smaller capacitor can be used. For example, Ralph uses a Mouser two section poly film variable capacitor with both sections wired in parallel for a maximum capacitance of 532 pF. But I like to use the old style metal frame air variables both for aesthetic reasons and because the mechanical rigidity is needed for stable operation with my phasing units. I also use air variable capacitors with a straight line or semi-straight line frequency. The shaft of these capacitors does not pass through the center of the metal plates, but is offset to one side, with teardrop plates for straight line frequency, and semicircle plates fo semi-straight line frequency. With these capacitors the tuning is not squeezed together at the high frequency end of the tuning range. And I use a Jackson Brothers dual speed planetary drive, 6:1/30:1, for loops which I plan to use with a phasing unit because the extremely low tuning rate is needed for phase adjustments to generate cardioid null patterns. If you do not plan to use the loop with phasing units, no tuning reduction is needed. The 660 pF value is not critical. You could use both sections of a two section 365 pF air variable, which would give a maximum capacitance of 730 pF.

The 2N3819 FETs are currently available at Radio Shack, as are MPF102s which work equally well. If you use MPF102s, be sure to observe that the pin out (G,S,D) is different than the 2N3819s. The JB dual speed drive is available from Radiokit for (gasp!) $18.00. Their catalog is $1, and their address is P.O. Box 973, Pelham, NH 03076. Other parts (metal boxes, 9 volt battery holders, etc.) are available from Radiokit and suppliers like Mouser. You can get a Mouser catalog by calling their toll-free number (800) 992-9943 if you live in the continental USA. For Alaska, Hawaii, Canada, and Puerto Rico call (800) 346-6873. With prices like $28.75 for Radiokit's two section 365 pF air variable (and I don't even know if it is semi-straight line frequency), one is inclined to shop around for less expensive parts. One of the nicest 660 pF air variables I have found recently is available from Antique Electrionic Supply, 6221 S. Maple Ave., Tempe, AZ 85283. The capacitor, catalog number CV-240, is a dual section 320/345 pF, priced at $4.65 each plus shipping. I believe the AES catalog is free. If you buy some of these capacitors, you will need to remove the old dried out grease with a suitable solvent and regrease the bearings because the original grease is so dry that shaft rotation is stiff and bumpy.