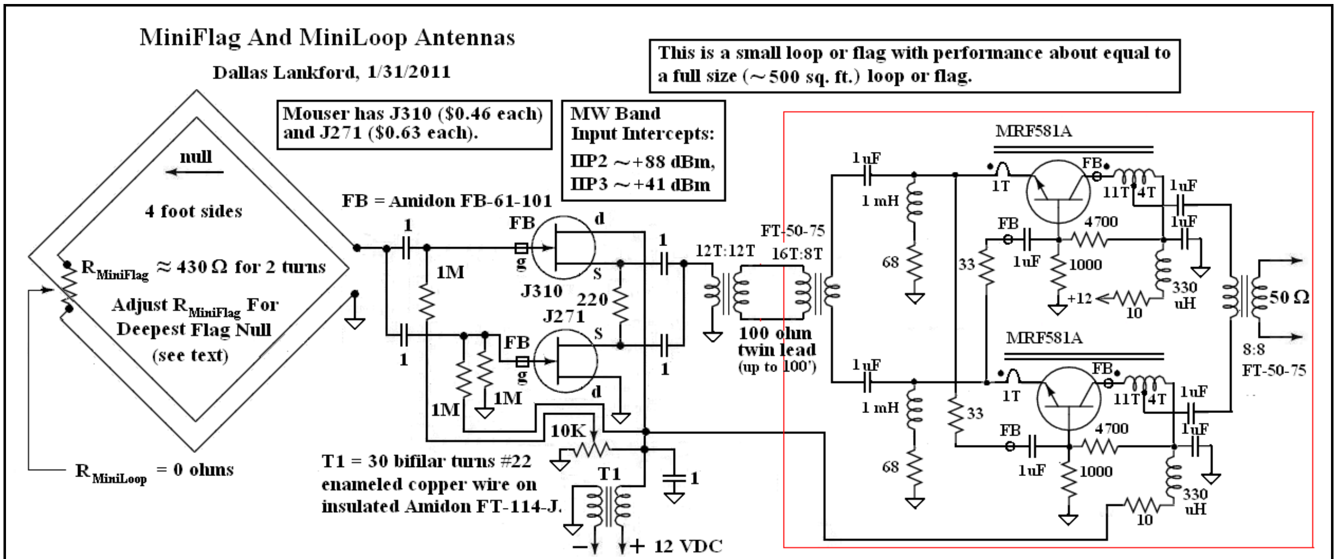
MiniFlag and MiniLoop Antennas

Dallas Lankford, 2/6/2011, rev. 3/7/2011



The amplifier inside the red box is a capacitor cross coupled push-pull Norton transformer feedback amplifier with about 13.5 dB gain and about 1.0 dB noise figure; see the article "Lankford-Ikin-Norton Feefdback Amplifiers" in The Dallas Files at www.kongsfjord.no . An ordinary push-pull Norton transformer feedback amplifier with about 10.7 dB gain and 2.0 dB noise figure can be used instead... they are available from KIWA Electronics and Clifton Laboratories (do a Google search if you are not familiar with them). The complementary J310 - J271 amplifier you will have to build for yourself... not dificult to do using the "dead bug" construction method. How to adjust the 10 K ohm pot for maximum IIP2 is discussed in the article "Hi Z PPLs + Hi Z Loop And Flag Arrays" in The Dallas Files. Other mini flag antenna artricles have been published before, but none like this one. The others used 16:1 step down transformers followed by traditional amplifiers, which cause about 18 dB voltage loss (6 dB loss due to the step down transformer impedance match, and 12 dB loss due to the voltage step down). The complementary high input impedance FET amplifier above has about -6 dB gain, which gives it a net gain of about 12 dB over the impedance matched transformer step down approach.. This means that the signal to noise ratio for weak signals is as much a 16 dB better than the impedance matched step down transformer approach. This approach, discussed in detail in the article "Hi Z PPLs + Hi Z Loop And Flag Arrays", also improves the signal to noise ratio of full size loops and flags.

After developing “High Z PPL's + Loop And Flag Arrays” (formerly “High Z PPL's + High Z Loop And Flag Arrays”) it occurred to me that those methods could be used to develop miniature flag and loop antennas with the same sensitivity and null properties as full size flag and loop antennas. The above figure describes my second mini-flag and mini-loop. The mini-flag has an appropriate terminating resistor to form the limaçon (cardioid-like) null pattern of a flag; the mini-loop has no resistor (0 ohms). The first version was a single turn square with 4 foot sides, which I judged to be insensitive. The second version was the 2 turn loop element above, which I judged to be adequately sensitive.

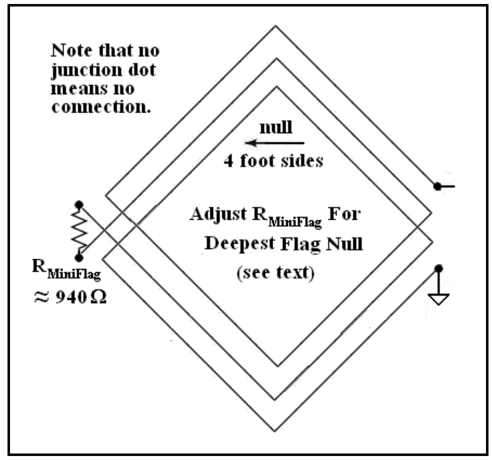
EZNEC simulation does not calculate accurate terminating resistor values for good mini-flag nulls. So you will have to use a potentiometer (I used a 1K pot) and wireless audio connected to your receiver and maximize the null depth on a distant (500 to 1000 miles) nighttime MW sky wave in the plane of the loop (I used Chicago on 720 kHz). Once set, the null depth is more or less maximized from one end of the MW band to the other. I suspect that the low end frequencies are better than the high end frequencies for determining $R_{MiniFlag}$. Once the null depth has been maximized (or should I say minimized?) with the potentiometer, take the pot inside, measure its resistance, and make the appropriate fixed resistor to install in your mini-flag by soldering together appropriate series and parallel resistors. For my two turn mini-flag above it was simple: a 330 ohm resistor in series with a 100 ohm resistor (the potentiometer value was actually 433 ohms... less than 0.1% is close enough).

Other mini-flag antennas have been developed previously, such as by W2PM and WA1ION, but they use 16:1 Z (800 ohms to 50 ohms) step down transformers. Preamps were undoubtedly used with those previous versions, but were not discussed in their descriptions.

My mini-flag above is a different design: there is no step down transformer, a high input impedance active whip amplifier is connected directly to the flag antenna terminals (avoiding the 4:1 or 12 dB voltage reduction of the step down transformer), and its low output impedance (about 150 ohms in the case of the complementary J310 –

J271 whip amp) matches well to low impedance amplifiers. The high Z active whip amplifier does not load the mini-flag, which provides another 6 dB increase in signal level. The high Z preamp has –6 dB gain, so the net gain is 12 dB compared to the transformer approach. The 2 turns give another 6 dB increase compared to a 1 turn mini-flag So this is like is like using a 18 dB gain 0 dB noise figure amplifier with a 1 turn step down transformer mini-flag of the same size. Of course, there are no 0 dB noise figure amplifiers, which gives a big advantage to my transformerless approach.

The LIN MRF581A amplifier does not need to be with the J310 – J271 preamplifier. It may be 100' or so away inside your house at your receiver. The LIN amplifier adds another 14 dB gain, which is necessary because of the low signal output of the flag and preamp. An ordinary 10.4 dB nominal gain Norton transformer feedback amplifier will work equally well without compromising the noise figure of the antenna system. Excessive gain with higher noise figure amplifiers will compromise the noise figure of the antenna system.



OJ asked, "What about 3 turns?" I assumed that another turn would add another 3.5 dB to the output. The 2 turn mini-flag has 6 dB more signal output than the 1 turn mini-flag, so the 3 turn mini-flag should have 9.5 dB more signal output than the 1 turn mini-flag. This is what theory predicts, but assumptions are sometimes wrong. And there is no substitute for measurement. To make a measurement, one has to decide where to put the terminating resistor, $R_{MiniFlag}$. I set up the 3 turns so that the resistor could be placed at the 1.5 turns (symmetric) position, or the 1 turn position. I wanted the maximum null depth for a 30 degree arrival angle. So I had to await sundown. I did make some measurements on ground waves before sundown, but the $R_{MiniFlag}$ values were quite different from the values I got after sky waves began to appear. The 940 Ω value specified in the figure at right is a first approximation, and may be change later if further measurements support a change. In any case, the 3 turns with the 940 Ω resistor and symmetric $R_{MiniFlag}$ position added about 3.5 dB more signal output than the 2 turn mini-flag. The 3 turns were wound as a spiral, in a single plane, with spacing about 1 inch between turns. I used the 1.5 turns (symmetric) position in the diagram above because the 1 turn position did not give 3.5 dB more signal output than the 2 turn mini-flag for the higher MW frequencies. The increase was more like 3 or 4 dB mid band, dropping off to no increase at the top end. However, the 1 turn position may be more desirable because it flattens the the flag signal output. As in the case of the two turn mini-flag, the null must be adjusted with a potentiometer using remote audio to listen you your receiver while the null depth is maximized on a distant nighttime MW station whose far away transmitting antenna is in the plane of the loop (the loop is "aimed" at the distant transmitting antenna)

In general, for n turns the additional gain compared to the 1 turn case is 20 log(n). For example, for 4 turns the additional gain will be 12 dB.

This morning, 2/3/2011, extensive tests were done with the 3 turn mini-flag in the 120 meter band for the Australians on 2310, 2326, and 2485, and for the N. Korean on 2850. All were in weakly, but with enough audio for a verification. A 1 meter high performance active whip antenna was compared to the mini-flag at the same time; the 1 meter active whip heard nothing but noise on all frequencies until a common mode choke was placed in series with the active whip coax lead. After that was done, performance was about equal except when the mini-flag null gave the mini-flag the edge. Clearly PPL mini-flags and PPL mini-loops are better choices than mini-whips as as compact DX antennas from the NDB band to HF because of their nulls.

If these multiple turn properties hold for full size flags, and I expect that they will, then multiple turns should provide another way to solve the low band insensitivity problem of the QDFA.

When the dust settles I plan to install a 7' x 7' (49 square feet) 1 turn diamond shaped mini-flag with 10' x 10' fir frame on a TV rotor on top of a 15' or so mast as an experimental MW beam antenna.