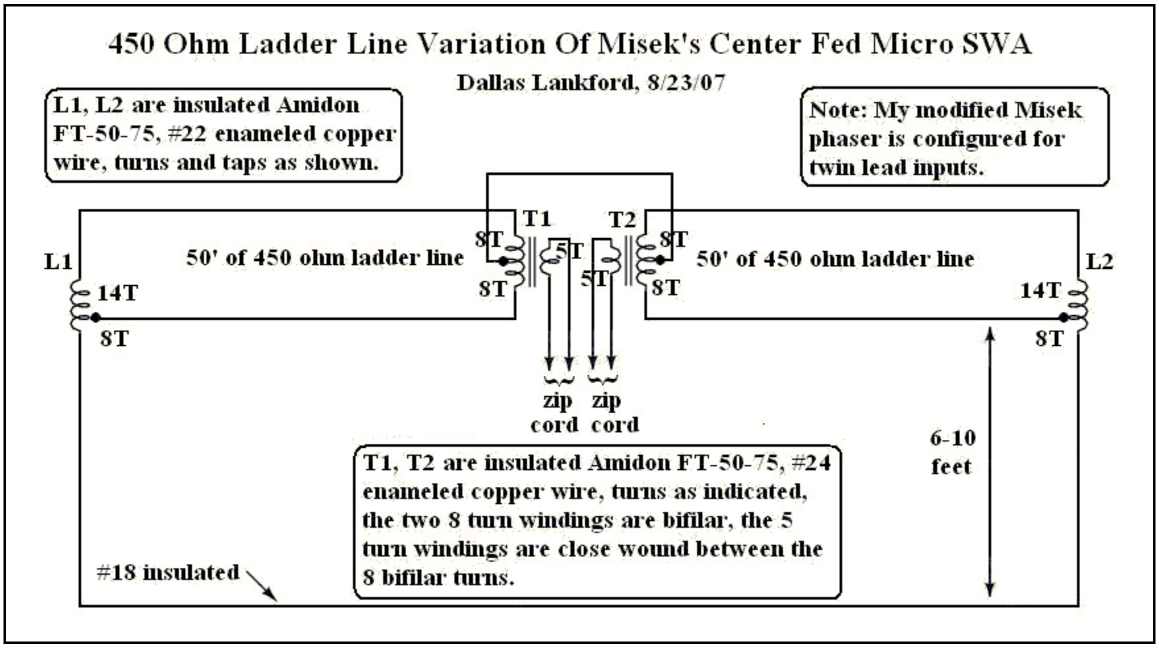
MW Tests With Variations Of Misek's Center Fed µSWAs

Dallas Lankford, 8/21/07, rev. 5/20/08

Over the years I have used many phased receiving antenna arrays for the MW band. Until tonight my best phased arrays were phased noise reducing vertical antennas separated by about 150 feet, followed closely by phased noise reducing inverted L's separated by about 150 feet. If you do not have much real estate, a vertical or inverted L and a loop, if closely matched in terms of signal output, are a good third choice because they do not have to be separated by more than a few feet. They are not as good as the first and second choices because the nulls of the vertical (or L) and loop are not as deep and not as stable as the first two. Separated loops, such as a pair of ALA-100 loop antennas separated by 40 meters, are rated fourth because their broadside nulls are sometimes poor, and because their null depths and stabilities are generally somewhat poorer than the first, second, and third choices. But then shortly after this was written, on 9/22/07, I discovered that a pair of short vertical antennas could be spaced as close as 60 feet and still produce excellent nulls throughout the entire MW band; see “Close Spaced Phased MW Vertical Receiving Antennas” in The Dallas Files .

Recently while reading the 2rd edition of **The Beverage Antenna Handbook** by Victor Misek I became curious if his micro steerable wave antennas would perform as well throughout the entire MW band as my best vertical phased array. Misek's design specified the antenna as 60 feet total length, using 12 inch spacing open wire line (home made), or 300 ohm TV twin lead, or 72 ohm twin lead, or 50 ohm coax. I did not have any of those, but instead 100 feet of 450 ohm ladder line. Tables in the beverage handbook did not specify transformers or tapped inductors for 450 ohm ladder line, so I interpolated. The output turns numbers were estimated for coax lead in, but I used (inexpensive) zip cord lead in. This also made it unnecessary to use Faraday shield output coax windings on T1 and T2. The zip cord impedance mismatch did not seem to matter. The bottom most wire of Misek's µSWA was grounded at each end by a 2 or 3 foot ground stake. Not having any spare ground rods, I did not ground my variation. My 450 ohm ladder line µSWA was oriented along a N-S line, the same as my phased verticals. The phasers originally used for these tests were modified Misek phasers, MW Phaser #2 and #4, which were described in articles in The Dallas Files , but are now retired because my new improved passive phasers are simpler to construct and work just as well. The tests were repeated for the 450 ohm ladder line µSWA below using a new improved passive phaser. The switched inductive coupling feature of the new improved passive phaser was necessary to obtain deep broadside nulls with the µSWA in some cases. 1:1 baluns were used to transform the zip cord lead in to the unbalanced inputs of the phasers: 8:8 turns of #22 enameled copper wire on insulated Amidon FT-50-75 ferrite toroids.


450 Ohm Ladder Line Variation Of Misek's Center Fed Micro SWA

Dallas Lankford, 8/23/07

L1, L2 are insulated Amidon FT-50-75, #22 enameled copper wire, turns and taps as shown.

Note: My modified Misek phaser is configured for twin lead inputs.

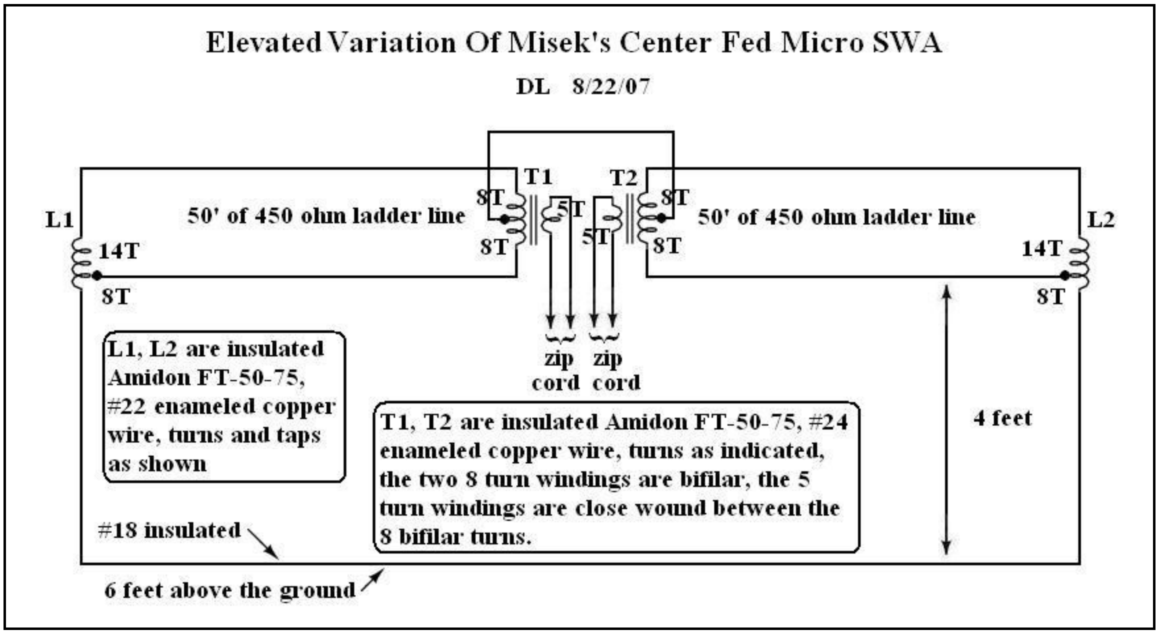
T1, T2 are insulated Amidon FT-50-75, #24 enameled copper wire, turns as indicated, the two 8 turn windings are bifilar, the 5 turn windings are close wound between the 8 bifilar turns.

The figure above describes my 450 ohm ladder line variation of Misek's center fed µSWA. Daytime comparisons of the 450Ω µSWA were done against my best phased array, a pair of noise reducing vertical antennas separated by about 150 feet, at about 1:30 pm (essentially high noon CDT in August). In the upper half of the MW band no differences between the µSWA and phased verticals were noted. In the lower half of the MW band broadside nulls with the µSWA produced some clear signals at other frequencies for which the phased verticals did not. I interpreted this as indicating that the µSWA produces a single broadside null at lower MW frequencies, since it is known that the verticals produce bidirectional broadside nulls. Also, the µSWA produced less splatter for some broadside nulls in the lower half of the MW band than the phased verticals. So for daytime groundwave MW nulling the µSWA was slightly better than the phased verticals for a few signals.

Nighttime comparisons of the 450Ω µSWA were also done with my best phased array, noise reducing verticals separated by about 150 feet. Nighttime skywave MW nulls of the N-S oriented µSWA were at least as good as the N-S spaced verticals, perhaps slightly better in a few cases.

The 450 ohm ladder line µSWA is excellent for null steering throughout the entire MW band when used with one of my modified Misek phasers or one of my new improved passive phasers. It is not know whether other phasers will produce equally good results when used with one of Misek's amazing µSWAs; probably not.

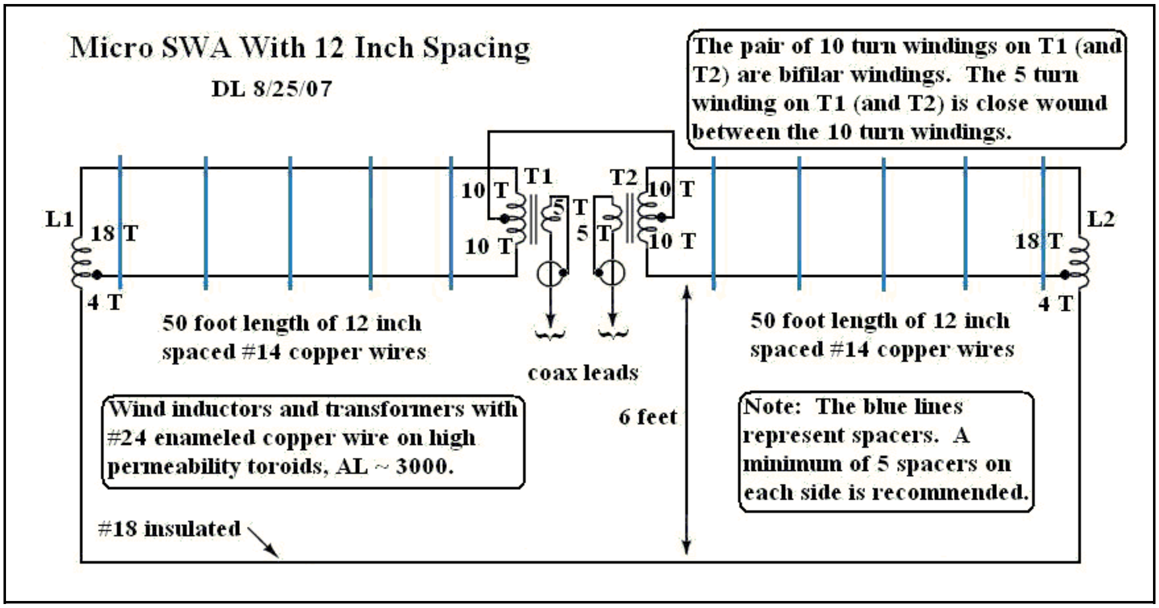
It not convenient for me to have a 100 foot length of insulated wire on the ground in my yard because the “ground” wire would have to be moved in order to mow the grass. So I decided to see if the “ground” wire could be elevated without degrading nulls. The figure below describes the elevated center fed µSWA which I implemented.



Daytime groundwave MW nulls of the elevated µSWA were about as good as the unelevated µSWA with wire on the ground except for some broadside nulls where, as before, the sideband splatter of the elevated µSWA was less than the phased verticals for a few signals. And, as before, the broadside nulls of the phased spaced verticals were bidirectional, while the broadside nulls of the elevated µSWA were unidirectional at lower MW frequencies, which I consider to be an advantage.

Nighttime skywave MW nulls of the elevated µSWA were no better than and no worse than the phased verticals for numerous test cases, including broadside nulls. The elevated version of Misek's µSWA is a winner.

Below is a coax lead in version using 12 inch spaced antenna wires. The numbers of turns for the transformers and inductors were taken from Misek's handbook. The spacers were 14 inch long 0.5 inch diameter hardwood dowels with holes drilled 1 inch from each end. The wire was Radio Shack #18 insulated (dual) speaker wire (pulled apart). The center was strain relieved with knots in the antenna wire and short lengths of 0.25 nylon rope. Not pretty, but it worked fine. The insulated ground wire was not pulled taught, and not grounded to ground rods at each end in the temporary prototype which was aligned E-W across my back yard. The center was about 3 feet off the ground, and the ends were about 6 feet off the ground. That considerable sag did not seem to degrade its nulls. Transformers, inductors, antenna wires, and lead in connections were soldered to pads cut onto small PC boards with a Dremel tool.


Micro SWA With 12 Inch Spacing

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The pair of 10 turn windings on T1 (and T2) are bifilar windings. The 5 turn winding on T1 (and T2) is close wound between the 10 turn windings.

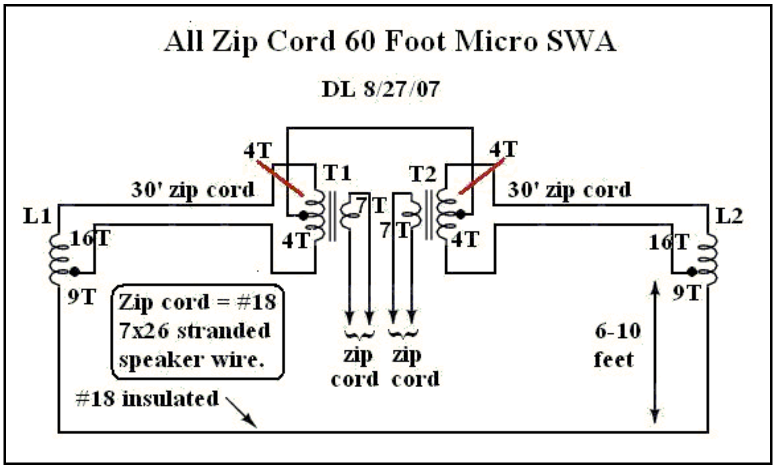
Wind inductors and transformers with #24 enameled copper wire on high permeability toroids, AL ~ 3000.

Note: The blue lines represent spacers. A minimum of 5 spacers on each side is recommended.

With both the N-S oriented µSWA and the N-S spaced verticals nulls towards the North and South are generally slightly better than nulls towards the East and west. Similarly, with the E-W oriented 12 inch spaced µSWA nulls towards the East and West are generally slightly better than nulls towards the North and South.

Daytime (and sunset and sunrise transitions) signal levels of the 100 foot MW µSWA antennas are sometimes low at my low noise location after nulling. So a 10 dB (nominal) gain high intercept amplifier is appropriate for my location, both for my modified Misek phasers and my new improved passive phasers. In some cases the passive phasers may benefit from additional amplification. I use push-pull Norton transformer feedback amplifiers for this purpose. A detailed article on how to build them is found in The Dallas Files, or you can buy them from Kiwa Electronics .

I got the idea for an all zip cord µSWA because zip cord (= #18 stranded speaker wire) is 100 ohms “nominal” impedance, and because Misek's beverage handbook has turns data for a 72 ohm twin lead µSWA impedance. The 100 foot long zip cord µSWA was a 100 foot spool of Radio Shack #18 stranded 7x26 copper speaker wire cut into 50 foot halves. Speaker wire twin lead is closer to 200 ohms, so my estimates of the turns numbers are not be accurate, but it doesn't seem to matter. The 100' all zip cord µSWA 4 to 6 feet above the ground with ground wire on the ground had daytime groundwave nulls and nighttime skywave nulls as good as the elevated µSWA and the the phased verticals.


All Zip Cord 60 Foot Micro SWA

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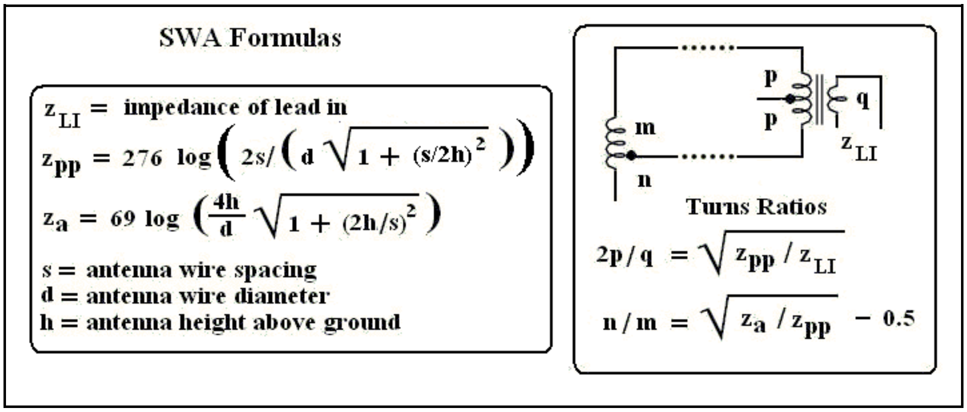
Zip cord = #18 7x26 stranded speaker wire.

How much shorter can a µSWA be made and still null as well as a 100 foot long µSWA (or a pair of phased separated verticals separated by 150 feet) throughout the entire MW band? In his beverage handbook Misek said that 60 feet total length was sufficient. After testing the 100' long all zip cord µSWA I cut it down to 60'. All of the transformer data in the figures above is valid for SWAs of any length, so the same transformers were used for the 60 foot µSWA as for the 100 foot version. The 60 foot µSWA, when placed about 15' away from and oriented in the same direction as the 100 foot elevated µSWA, nulled just as well, with the same signal to noise ratio, and with no decrease in signal levels. It is amazing, just amazing, that such a small antenna can generate such good MW nulls and steer them so well. The small 60 foot all zip cord µSWA was easy to move around my yard to test different placements and orientations. For daytime MW groundwave signals placement or orientation of the 60' all zip cord µSWA made as much as 10 dB difference on signal to man made noise ratios for some signals. In some cases the improved (or degraded) signal to noise ratios seemed to be due to placement of the 60' µSWA in a region of lower man made noise, and in other cases it seemed to be due to directionality of the 60' µSWA (partial nulling of the noise). Curiously the E-W orientation of the 60' all zip cord µSWA did not perform as well on some daytime groundwave signals at the lower end of the MW band as I expected compared to the 100' N-S 450 ohm ladder line µSWA,

And what is the minimum separation between the antenna and ground wires while maintaining good performance? I shortened the ground wire separation of the 12 inch spaced uSWA to 1 foot and the nulling performance was severely degraded; when a daytime groundwave signal was nulled, all other signals were nulled almost as much. So 3 feet at the center and 6 feet at the ends is about the minimum separation which should be used between the ground wire and the antenna wires.

All of the µSWAs which I tested provided good signal levels for SW signals, although slightly less than the verticals in a few cases. The µSWAs also seemed to provide nulling capability for man made noise and my neighbors noise sources even at the higher SW frequencies. Of course, none of them, including the verticals, produced decent SW nulls. No surprise there. Deep and stable SW skywave nulls are virtually impossible because of multiple arrival angles and the shorter wavelengths of SW signals. Nevertheless, a µSWA will provide reasonably good SW listening if you get bored with MW listening.

I like the 450 ohm ladder line version because its wire is solid copper clad steel #18 AGW, which gives it excellent strength. It should withstand wind and other stresses quite well. However, it is not very flexible, so if you want a portable µSWA which you can take to an ocean beach or to a remote site, then a stranded copper plated steel 450 ohm ladder line, or an all zip cord version would probably be more appropriate. You should also take along a 10 dB nominal gain preamplifier as mentioned earlier in this article to use between your phaser and receiver, just in case a few weak ones might otherwise get away.



SWA Formulas

z_{LI} = impedance of lead in

$$z_{pp} = 276 \log\left(2s/\left(d\sqrt{1 + (s/2h)^2}\right)\right)$$

$$z_a = 69 \log\left(\frac{4h}{d}\sqrt{1 + (2h/s)^2}\right)$$

s = antenna wire spacing
d = antenna wire diameter
h = antenna height above ground

Turns Ratios

$$2p/q = \sqrt{z_{pp} / z_{LI}}$$

$$n/m = \sqrt{z_a / z_{pp}} - 0.5$$

The SWA push pull impedance z_{pp} and antenna impedance z_a formulas were given in Misek's handbooks. The turns ratios formulas were derived from data in Misek's handbooks. Consider, for example, a zip cord SWA. Radio Shack #18 speaker wire which I use has d 0.045” and s = 0.155”. Using the impedance formulas at right z_{pp} = 231ohms and z_a = 227 ohms. And using the turns ratios formulas at right 2p/q = 2.15 for 50 ohm coax and n/m = 0.49. The number of turns q (which determines the number of turns p) should have a reactance on the order of 4 times (according to some sources) the lead in impedance, which is 50 ohms in this case. An FT-50-75 with q = 8 turns is about 192 ohms at 500 kHz. I have found this to be more than sufficient for matching 50 ohms down to at least 200 kHz. Consequently, q = 8 and p = 8 x 1.075 = 8 turns are sufficient. To match 231 ohm zip cord lead in p = 4. The values calculated here are in reasonable agreement with the interpolated values p = 4 and q = 7 obtained above. The number of turns m should have a reactance on the order of 4 times (again, according to some sources) the push pull impedance of the SWA. An FT-50-75 with m = 16 turns is about 2412 ohms which is much more than 4 times the push pull impedance. Consequently, m = 16 and n = 0.49 x 16 = 8 turns are considerably more than sufficient, and m = 10 and n = 5 should be sufficient. Because these are receiving antennas, it doesn't really matter if you match for coax or 200 ohm speaker wire twin lead. I have not changed the interpolated turns ratios for the zip cord SWA given above because it is unlikely that the calculated turns ratios would give any significant improvement. The turns ratio formulas were derived merely as a matter of curiosity.