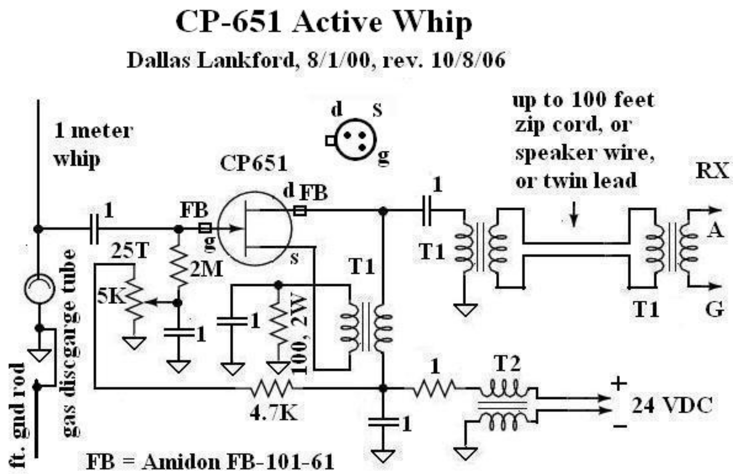
Some Of My Favorite Small Antennas For MW And LW

Dallas Lankford, 10/2/06, rev. 4/29/07

The purpose of this note is to describe some of my favorite small antennas for MW and LW.



gas discharge tube = Xicon gas tube surge arrestor, Mouser # 444-GT-90L

T1 (quantity 3 needed) = 8 bifilar turns #24 enameled copper wire on insulated Amidon FT-50-75 or equivalent (MiniCircuits T1-6)

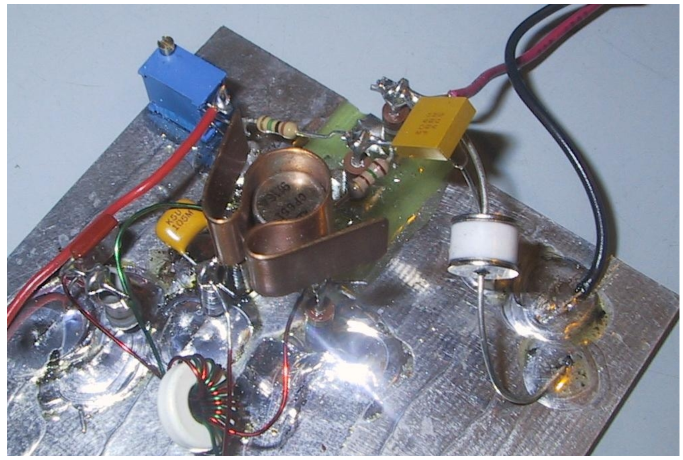
T2 = 30 bifilar turns #22 enameled copper wire on insulated Amidon FT-114-75 or -J or equivalent

Adjust 5K pot for 0.065 VDC across 1 ohm resistor connected to positive lead of T2.

The CP651 FET should probably be heat sinked. I used a Wakefield 207CB which may be discontinued. You should be able to make something suitable out of copper sheet.

I have designed and built many active whip antennas over the years, and this is one of the best in terms of intercepts. (There is a better one, but I agreed to non-disclosure for it, so that is the end of that.) My active whip design was inspired by earlier designs of Burhans, but is considerably different from his designs. In later versions I used Crystalonics CP664 FET's with no observed changes in performance. Apparently any CP6xx FET can be used with equal performance. The DC power feed should be decoupled from the DC power supply as shown; otherwise the active whip's signal to man made noise ratio may and probably will be degraded 10 to 15 dB or more. I appreciate Nick Hall-Patch asking me about certain aspects of noise in active whips which motivated me to revise earlier schematics in order to to clarify my understanding of the noise issue at that time. In the past I have called this excess noise ground loop noise, and I have used a pair of 1 mH chokes instead of T2 to suppress this noise. However, recently it was pointed out to me by Terry Fugate, WN4ISX that the noise I observe when not using the chokes is called common mode noise. Terry also introduced me to the unpublished work of Chuck Counselman, W1HIS, “Common-mode Chokes.” When common mode noise occurs on twin lead, as is the case for this active whip, bifilar windings on a toroid may be used to suppress the noise, which I did a few days ago with T2. The 30 bifilar turns on an FT-114-75 form two chokes with about 2.7 mH inductance each, or about 2500 ohms reactance at 150 kHz. This does not seem to be sufficient to eliminate all common mode noise at the low end of the NDB band at my location (Chuck recommends 6000 ohms reactance or more at the lowest operating frequency), but it does seem to be enough for the entire MW band and higher frequencies at my location based on measurements of received man made noise with and without T2 and comparisons to non-active noise reducing vertical antennas. For example, adding T2 in series with the original 1 mH chokes improved the man made signal to noise ratio by slightly more than 5 dB at the low end of the MW band; it did not improve the man made signal to noise ratio at the high end of the MW band or at higher frequencies. If I were to use this or a similar active whip where the twin lead in ran through an extremely noise location, I would use shielded twinax and consider taking additional measures to reduce common mode noise on the signal lead in. For routine noise, like at my house, a common mode bifilar choke on the twin signal lead lead in was not found to be necessary. Several people have reported more noise reduction when using an 8 foot commercial ground rod. I use 8 foot commercial ground rods cut in half (one with its flat cut sharpened to a point) because I do a lot of experimenting with antennas, and it is easier to remove a 4 foot ground rod from the ground (with a big pipe wrench) than an 8 foot ground rod (usually impossible to remove).

At right is a photo of an "ugly" constructed CP651 active whip set up for intercept measurements. The PC board is not etched, but uses 4.7 M resistors soldered to the tinned PC board as insulated standoffs. Isolated pads at the input of the FET were cut with a Dremmel tool for the gate standoff, and epoxied with 10 minute clear epoxy to restore PC board strength. The 10 turn pot was epoxied to the PC board after soldering the bottom lead to the PC board. The CP651 probably does not need a heat sink when drawing only 40 mA, but I used one anyway. The heat sink was made from copper gutter flashing stock cut with scissors and formed with drill bit butts.



Push-Pull CP651* Active Dipole *or CP664 etc.

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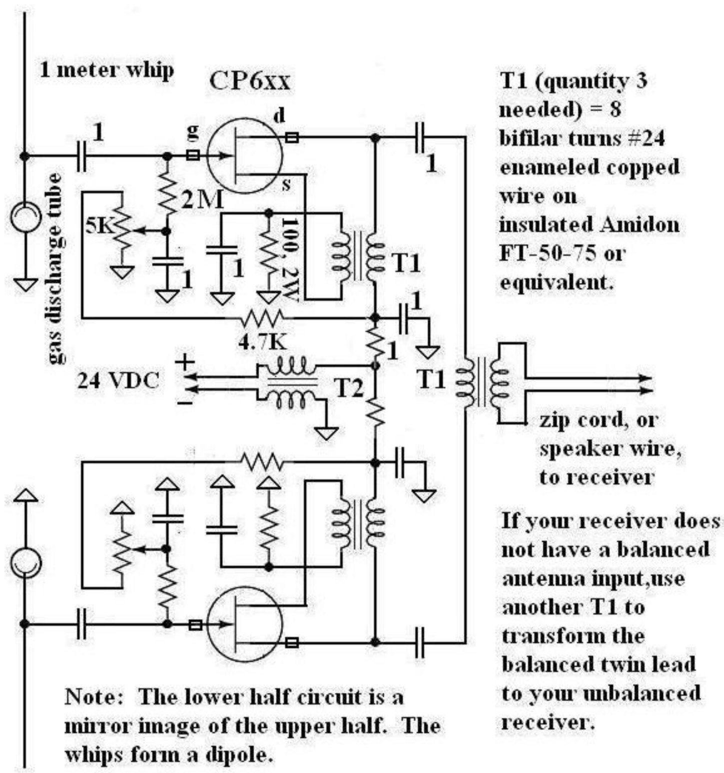


T2 (quantity 1 needed) = 30 bifilatr turns #22 enameled copper wire on insulated Amidon FT-114-75 or -J or equivalent.

A few days after I built the CP651 active whip in August 2K I decided to built an active dipole using two of the active whips and a balun. I wanted to know if a push-pull active circuit would have higher 2nd order intercepts (it did), and if an active dipole would have figure 8 reception pattern similar to a loop antenna (it did). I also wanted to know if it would be a good antenna to use with a whip for LW null steering with my modified Misek phaser (it was).

Curiously the active dipole produced lower groundwave (daytime) signal levels in the upper half of the MW band than the active whip; I do not know if this is because an active dipole is less sensitive to vertical polarization, or because of some other reason. Skywave (nighttime) MW signal levels were about the same for both the active whip and active dipole. When the dipole was mounted vertically, groundwave (daytime) signal levels throughout the MW band were about the same as the whip. Later I found a short article, "Horizointal Antennas Above Real Ground, by Ralph Holland, *Amateur Radio*, Vol. 64, No. 10, Oct. 1996 from which I quote as follows. "Horizontal antennas are subjected to the influence of a broadsize image in the ground. The antenna and its image are in anti-phase, so radiation tends to be cancelled at low angles and the radiation resistance is lowered because the mutual impedance of the image is subtracted from the self-impedance of the driven element." This also could account for the lower groundwave (daytime) signal levels in the upper half of the MW band produced by active dipole antennas compared to acrive whip antennas.

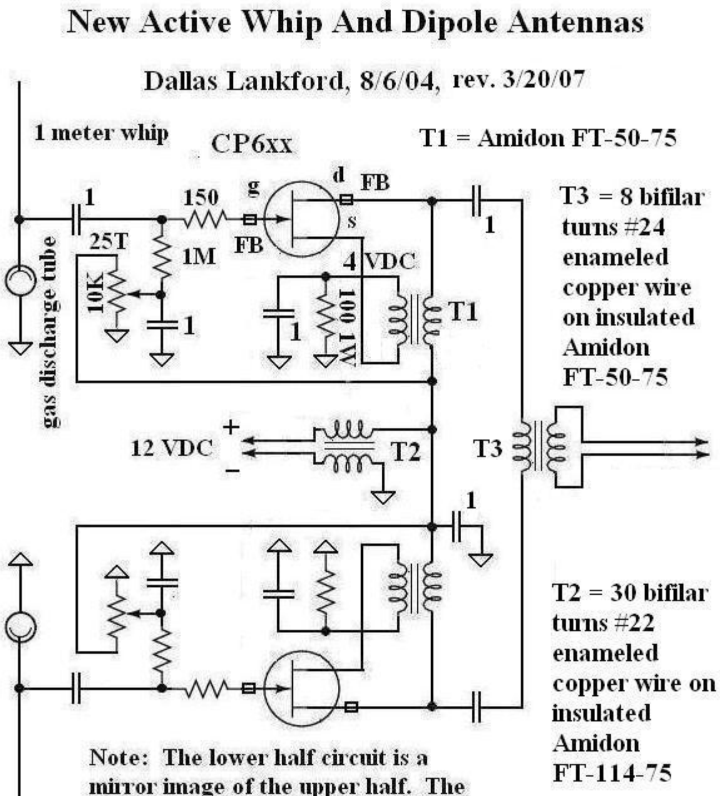
Based on recent measurements by Terry and me, a ground rod does not improve the signal to man made noise ratio of this active dipole.

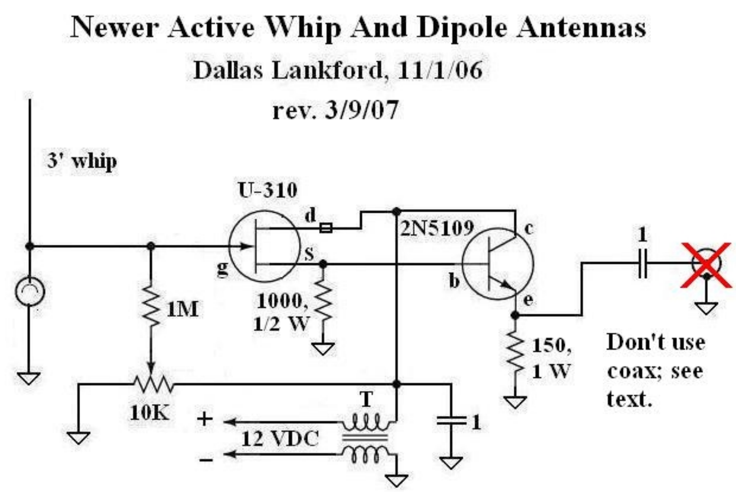
Four years later (8/3/04) I had another go at CP6xx active antennas. First, this one uses a 12 VDC power supply, compared to the 24 VDC power supply used by my earlier CP6xx whip and dipole. Second, half of this dipole makes a good active whip antenna, about as good as the previous 24 VDC whip. Third, this (these) active antenna(s) has (have) parasitic suppression, the 150 ohm resistor(s) at the gates. Fourth, the current per FET is adjusted for 40 mA, so no heat sink should be needed.

Based on recent measurements by Terry and me, a ground rod does not improve the signal to man made noise ratio of this active dipole.

One of the mirror images can be used as an active whip. This active whip should have a ground rod, like the other one.

Below is the schematic of another 12 volt whip or dipole. Also this one uses a more common and less expensive U-310 FET, and no transformers for the whip. With the 12 VDC power supply IIP3 = +43 dBm, IIP2 = +71 dBm, and gain is about -5 dB. If used with a 24 VDC power supply, IIP3 is about +48 dBm and IIP2 is about +88 dBm. Intercept measurements were done in the MW band with a 6 pF capacitor simulating a 1 meter whip element length. For a dipole, build a second whip, oppose the whips, and join the two outputs with a balun. This version is shown with coax output. A balun would be used for twin lead output. The 25 turn pot is adjusted for minimum 2nd order intermod. This occurs at about 60 mA current drain for the 2N5109 with a 12 VDC power supply, so a heat sink is advisable. The U-310 draws about 18 mA @ 12 VDC, and while it runs quite warm to the touch, a heat sink is not really necessary.

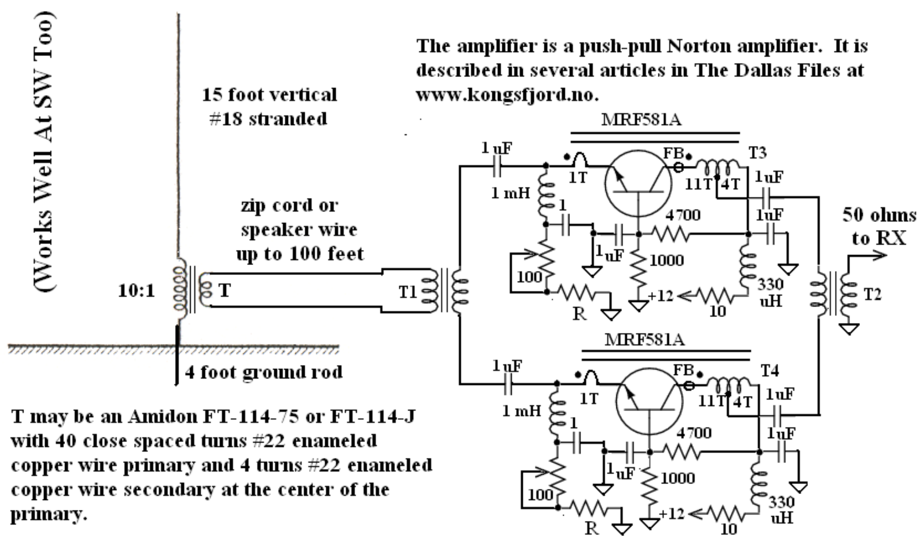




These antennas are not finished products, but rather are works in progress. My experiments with active antennas have been interesting, but I still recommend passive antennas wherever possible. For example, I have a pulsed noise source that sometimes shows up at night on my non-active antennas in the MW and LW bands. I think it is my security light, and intend to have my power company disconnect it to determine if my suspicion is correct. Curiously, my active whip antennas sometimes heard the pulsed noise source in the MW and NDB (LW) bands (quite strong at the low end of the NDB) during testing when my non-active antennas did not. The active whip antennas heard the pulsed noise source even when operating on battery power. So it seems that the noise path into the active whips may not be via common mode. Also, I don't believe the noise path into the active whips are via near field either because all the antennas, active and non-active, are close enough together so that they should be more or less equally within the near field of the pulsed noise source at the low end of the NDB if the near field is in fact the cause of the man made noise. Why do the active whip antennas hear the pulsed noise while the non-active antennas do not? At present I do not know. But this does illustrate why active whip antennas are not the primary MW DX antennas in my yard. The 12 volt active whips are, however, excellent antennas at remote locations away from sources of man made noise, say, at a beach well away from man made noise sources, or at the game preserve about 10 miles South of my house, powered by my car battery. Because of these experiences, and because Terry told me that the CP6xx active dipoles described above had better signal to man made noise ratios at his location than the active whips, I resurrected one of my active dipoles. It also heard the pulsed noise source on AC power using common mode chokes when my non-active antennas did not. But the pulsed noise seemed much weaker on the active (horizontal) dipole when using battery power. For weak daytime NDB's the active dipole mounted vertically had a better man made signal to noise ratio.

At right is a schematic of an experiment to see how short I could make a noise reducing vertical antenna while maintaining good sensitivity using only a 10.8 dB gain push-pull Norton amplifier to bring signal levels back up to a good level. It worked out very well. One of the reasons I like this antenna system is because no heat sinks are needed for the MRF581A's. Another reason I like this antenna system is that it seems to be free of common mode noise problems I have experienced with the active whip antennas above. This amplified short noise reducing vertical was tested with twin lead up to 100 feet in length, so a pair of these separated by about 150 feet make a good MW phased array. If you are not a builder, you can buy an equivalent Norton amp from Kiwa Electronics for about $110 plus shipping (as of October 2006).

Short Amplified High Performance MW And LW Vertical Antenna



Later... The pulsed noise source mentioned above is gone. It was my security light, just as I suspected. Apparently the photocell security light switch which my power company is using in its security lights puts out large amounts of pulsed noise in the MW band and below when the switch is on.

However, some (different) noise remained at the lower end of the NDB band, both day and night. That noise turned out to be associated with AC-DC power supplies; see my article on low noise AC-DC powetr supplies in The Dallas Files .

Just when I thought I had tamed active antenna man made noise pick up in the lower NDB and below with low noise AC-DC power supplies a new noise source in the lower NDB band and below appeared. I don't know where it is coming from, or how it is entering my active antennas, but it has caused me to reconsider using active antennas as my primary antennas. If your neighbors are not noise sources, or if you want a neat portable antenna to take to quiet listening locations, then an active whip or dipole may be a good choice. Otherwise, a noise reducing vertical or inverted L antenna appears to be a better choice. If a smaller noise reducing antenna is needed or desired, a 15 foot noise reducing vertical with push-pull Norton amp is an equally good choice. Another reason to opt for a non-active noise reducing antenna is that their intercepts are not degraded when used with a high intercept filter, while active antenna intercepts, especially 2nd order intercepts, are degraded when used with a high intercept filter.

Today 4/29/07 while studying active whip intercepts I discovered, much to my amazement, that long coax (50 feet) lead in generally degrades 2nd order intercepts of active whip antennas by 20 dB or more and degrades 3rd order intercepts of active whip antennas by 10 dB or more, depending on the type of active whip antenna. I have not studied the cases of longer coax lead in, or long coax lead in used with active dipoles, or long coax lead in used with (passive) noise reducing antennas. For active whips long (50 feet) twin lead lead in does not change 2nd or 3rd order intercepts. I have not studied the cases for longer twin lead lead in with active whips, or for twin lead lead in used with active dipoles or (passive) noise reducing antennas. I rather expect, of course, that coax lead in will be a loser with respect to intercepts in all of those cases, while twin lead lead in will be a winner with respect to intercepts in those cases. Of course, if you don't listen in a high RF environment, then it may not matter if you use coax lead in.