evaluation of

simple dx antennas

for

40 and 80 meters

DX is possible on 40 and 80 meters with a variety of antennas designed around practical limitations

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The introduction of awards by several organizations for recognition of multiple band DX capability have considerably diversified the antenna farm of the serious DX man. Working DX on 10, 15 and 20 meters is no problem using the popular three-band beam and an average station. Things get more difficult, though, as you move inland from the east or west coast. Due to the deterioration of signals as they are propagated over land at low frequencies, amateurs in the interior require antennas more elaborate than a dipole at 25 feet to compete with their colleagues in more advantageous geographical locations.

a proposed solution

A survey of available commercial low-frequency DX antennas revealed that most were an electrical compromise and were also expensive. There was also the problem of compatibility with the present tower-rotator-tribander configuration. I looked to see what could be homebrewed. The results were somewhat discouraging — I didn't have a tuner, a 100-foot tower, 20,000 feet of wire or a big lot. The only simple low-frequency antennas which were useful as DX antennas and could be considered constructionally feasible were the vertical, the horizontal wire beam and the sloped dipole. I developed the following test plan: First, to construct simple wirebeam, ground-plane and sloped-dipole antennas for 40 meters, and to determine which antenna was the most effective for DX. Second, to extend the 40-meter ground plane to about 60 feet to act as quarter-wave radiator on 80 meters and to attempt to use the same antenna as something close to a 5/8-wave vertical on 40. Next, I wanted to determine how well the ground plane worked on 80 and if the 5/8-wave vertical is more effective on 40 than the quarter-wave ground plane. Last, I wanted to construct a sloped-dipole for 80 meters to compare with the ground plane for the same band. I did not try a wire-beam configuration on 80 because of its large size and generally unfavorable comments in the literature.[1]

two element wire beam

The *ARRL Antenna Book* contains a simple two-element wire beam in the chapter on 14-, 21- and 28-MHz antennas.[2] Extending the concept to 40 meters was easy. The original design for the two-element folded dipole beam specified that the radiating elements should be constructed of number-12 wire, spaced 3 to 6 inches. Constructing something of this nature appeared to be a lot of work, so I used regular 300-ohm twin-lead instead. As an effective flat-top configuration required four poles of at least 60 feet, I tried an inverted-vee array using a boom for proper spacing.

The boom was assembled from an old tv mast and two sections of conduit. I installed pulleys on the boom so that the folded dipoles could be pulled out to the proper spacing from the tower. I attached the boom to the tower as follows: I mounted an eyebolt through the center of gravity of the boom and attached an 18 inch threaded rod to the tower at the 55-foot level. The rod was attached with U-bolts, with about 6 inches to the threaded rod extending from the tower. The eyebolt on the boom was then slipped over the threaded rod and secured with two bolts.

Stability of the boom was improved by installation of a wooden beam as shown in **fig. 1**. The length of the wooden beam is dependent on the desired orientation of the boom. The ends of the boom drooped, of course, so I added two eyebolts five feet from either end. Cables attached to the eyebolts were connected to the tower at the 70-foot level. Axial tension was increased by turnbuckles. Once the folded dipoles were in place on the boom and the ends attached to trees, each leg of the dipoles made a 30° angle with the horizontal.

Electrically, the antenna consists of

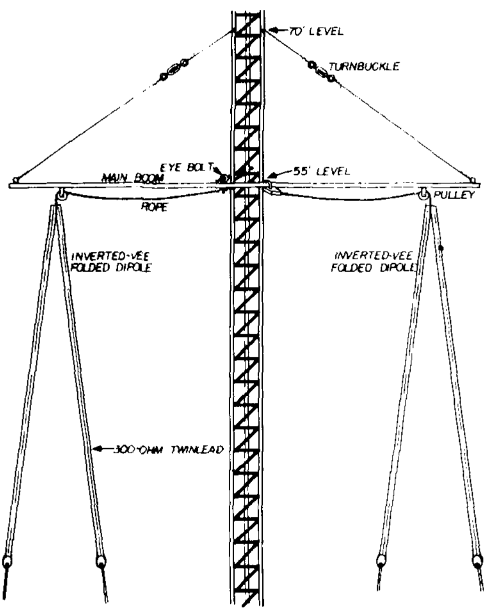
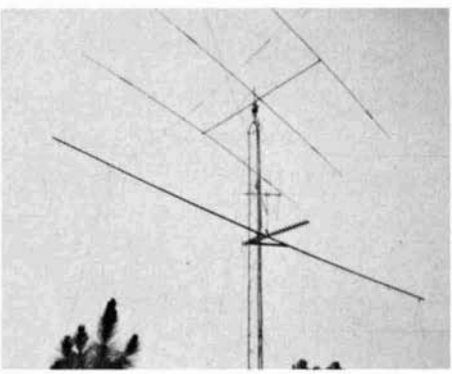


fig. 1. Wire beam for 40 meters uses two inverted-vee folded dipoles made from 300-ohm twinlead. Boom is attached to tower as shown in fig. 2.

two inverted-vee folded dipoles spaced a quarter-wave apart. The length of the feedline to the folded dipole which is the back element of the beam is a quarter-wave longer than the feedline going to the folded dipole which is the front element of the beam. The major radiation lobe is off of the front element. The feed impedance for the original flat-top configuration was 150 ohms. Since I didn't have any 150-ohm twin lead, and since I had no idea what the impedance would be for the modified array, I tried feeding the antenna with 72-ohm twinlead. The swr was very high.

I tried 300-ohm twinlead and the swr was 1.5:1 at the resonant frequency. The dipoles were originally cut for 7150 kHz but the resonant frequency was about 6950 kHz. This was anticipated because inverted vees have lower resonant frequencies than dipoles for the same antenna length. Six inches removed from each end of each dipole moved the resonant frequency to 7050 kHz. The swr was 1.5:1 at 7050 kHz and 3:1 at 7300 kHz, which was acceptable. I speculated



Installation of the folded-dipole inverted-vee antenna at W5RUB. The two folded dipoles are suspended from a boom mounted on the side of the tower at the 55-foot level (see fig. 1).

that possibly the swr measured at the end of the 300-ohm transmission line and the feed point of the antenna were different, but an swr measurement at the feedpoint indicated that they were practically the same. A dpdt relay was installed at the feedpoint so I could reverse the direction of the major radiation lobe.

40 meter ground plane

Next, I built the ground plane. The antenna was made by topping off a 50-foot push-up tv mast with a 21-foot CB whip. The radiating element for 7 MHz is only 33 feet, but the additional height was necessary so the antenna could be used as an 80-meter ground plane in future tests. The mast was guyed only at the ten-foot level during the 7-MHz tests. Unfortunately, the top section of the tv mast and the bottom section of the CB whip were the same diameter so they had to be joined with a section on one-inch inner diameter copper tubing.

Ground losses for vertical radiators can be significantly reduced by using artificial grounds like a ground plane. It is wise to erect an array of this nature as far above ground as possible. One common location for a ground-plane antenna is on the peak of the roof. Many people feel, however, that radials spread out on the roof detract from the house's appearance.

To avoid this problem the 40-meter quarter-wave radials were apprehensively installed on the ceiling of the attic. Not knowing the electromagnetic properties of my roof (asbestos shingles, tar paper and plywood), I anticipated assorted gremlins, but none have been observed. Ten 33-foot radials were attached to the ceiling of the attic spaced 30 to 40 degrees apart – some being bent to fit the available area of 30 x 70 feet. If an open area is available for erection of the ground plane, by all means use it, but if yard space or aesthetic arguments are a problem, the attic provides a good alternative.

Insulating the vertical radiator from the roof was another problem. After some experimentation, the best solution appeared to be a roof saddle with a U-flange and some method of insulating the U-flange from the vertical. The best solution was an ordinary automobile rear shock absorber with rubber inserts on the mounting eyes. Using the shock absorber, a quarter-inch bolt was inserted successively through one side of the U-flange, the lower rubber insert and the other side of the U-flange. A hole slightly larger than a quarter inch was then drilled in both sides of the bottom section of the 50-foot tv mast about six inches from the bottom end (see **fig. 3**). The bottom section was then slipped over the shock absorber and a bolt inserted through one of the previously drilled holes in the mast, through the upper rubber insert of the shock absorber and out the other side of the mast. Thus, once erected, the vertical was insulated from the roof.

If your roof is guaranteed to be a good insulator this ritual is not necessary, and the vertical can simply be attached to the U-flange. A hole was drilled, under a shingle, through the roof and a number-ten wire was inserted to connect the vertical element with the transmission line. Plenty of plastic roof cement was applied to the modified part of the roof. The ground plane was fed with 52-ohm coax (which was also in the attic). No reflected power was observed at the calculated resonant frequency.

the sloped dipole

The sloped dipole configuration consisted of a simple folded dipole attached between one point 47 feet up the tower and another point 47 feet from the base of the tower. Hence, it made an angle of 45° with the horizontal with the major radiation lobe for the antenna in the direction of the slope.

performance comparison

The relative merits of antennas are usually evaluated in terms of field strengths at various angles and distances from the point source of the radiation. However, the major object of this exercise was to work DX with a minimum amount of blood-letting, hence, whichever antenna had the best punch was obviously the best antenna.

The sloped dipole and one major lobe of the beam were oriented towards Europe which is the major source of long-haul DX from Mississippi. Averaged reports received from Europe indicate that the sloped dipole and the ground plane are equally effective. The average report for the two antennas ran about one S-unit higher than the faithful inverted vee at 65 feet. The two-element wire beam generated average reports which were two S-units higher than the inverted vee and one S-unit higher than the sloped dipole or ground plane. Included angles of other than 45° might be tried with the sloped dipole. No optimum angle has been published for 40 meters as far as I know.

The sloped dipole is economical and easy to erect if a 50-foot support is available. This antenna provides some reduction of stateside interference and a worthwhile increase of signal strength on distant propagation paths as compared with an inverted vee or dipole at a comparable height. The ground plane requires very little erection area (if the radials are in the attic) and provides a tremendous reduction in stateside interference. This antenna is a good omnidirectional performer for the DX man who does not have much space or has no

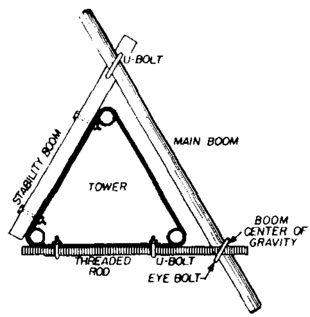


fig. 2. Boom for wire beam is attached to tower with an eyebolt and threaded rod. Short piece of wood is used for stability boom. See text for complete description.

means of raising an antenna to 50 or 60 feet.

The two-element wire beam takes up a lot of room and takes quite a bit of erection effort, but this is a good antenna to have in a pileup. Two of these antennas mounted perpendicularly to each other will provide excellent worldwide coverage on 40 meters. Rejection of signals off the side is good and fair off the back. Stateside interference, of course, increases off the front and this is sometimes a problem if the East Coast is between you and Europe. Many times I have worked Europeans who could only hear me on the wire beam, but I could hear them only on the ground plane.

On the other hand, the beam is a great contest antenna. I have often found as a stateside contest winds down on the higher frequencies and you are forced to go to the lower frequencies in search of contacts, it is sometimes difficult to work the East Coast until a couple of hours after sunset. This is because much activity is concentrated in the 1-2-3-8 and upper 4 call areas and the signals are so strong within this area that signals from the outside are buried in the interference. The beam is a very effective aid for getting the attention of the East Coast community both in the hours near sunset and later in the evening.

dual-band antenna

As previously mentioned, the 40-meter

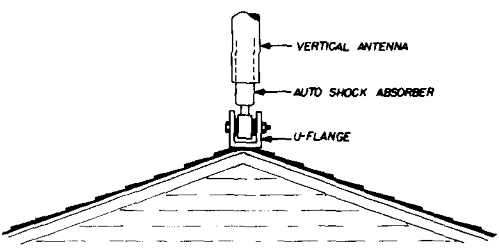


fig. 3. Vertical antenna is insulated from roof with an old automobile shock absorber with a rubber bushing.

ground plane was constructed so it could be converted to an 80-meter ground plane and something close to a 5/8-wave vertical for 40 simply by extending the push-up tv mast. The 5/8-wave on 40 is significant because at that length maximum low-angle radiation occurs.[3] The vertical was raised to 60 feet and the antenna was guyed at 10 and 28 feet. The guys were attached to eyebolts in the roof some 15 feet from the base of the antenna. The eyebolts were anchored in the rafters and plastic roof cement applied around the eyebolt on the roof surface. The vertical was insulated from the guy wires by egg insulators which were placed in each guy wire about six inches from the vertical. Six feet of the fourth section and five feet of the fifth section of the tv mast and the 21-foot CB whip were left unguyed. The 32 feet of unguyed antenna have presented no stability problems and the antenna has sustained gusts to 70 mph without damage. The lower three sections of the tv mast were extended to the maximum attainable length which came to about 28 feet total, but the fourth and fifth sections were extended to only six and five feet respectively in order to keep down the number of guy wires.

A dpdt relay was installed at the base of the ground plane (in the attic) to switch between the 40- and 80-meter matching circuits. The 40-meter configuration required a simple L-network to match the 5/8-wave vertical to the 52-ohm coax.[4] On 80 a small loading coil was necessary because the vertical was electrically short at 3.5 MHz.

Operation of the extended vertical on 40 indicated that no increased effectiveness was apparent as compared with the quarter-wave vertical. This conclusion was based on comparison with the 40-meter sloped dipole. Therefore, if you don't plan to use the vertical as a ground plane on 80, the extended vertical is not worth the effort.

ground system

Contrary to popular opinion, radials shorter than one-quarterwave can be effectively used in a ground plane antenna configuration provided the vertical radiator is *at least* 1/5 wavelength or longer. No problem was experienced in loading the 80-meter vertical against the 40-meter ground system using the L-network. I worked a lot of DX on 80 using this configuration. Some weeks later, fifteen quarter-wave radials were added to the system making it a true 80-meter ground plane. This made a total of fifteen 80-meter radials and ten 40-meter radials. Reports received from DX stations were somewhat better, but I am not sure whether the improvement was due to increasing the number of radials or adding longer radials. It is interesting to note in Lee's work[3] that increasing the length of radials from 1/8 to 1/4 wavelength increases the unattenuated field for a vertical radiator at one mile by 5 millivolts per mile while doubling the number of quarterwave radials from 15 to 30 provides a 12 millivolt per mile increase. Agreed, we are comparing apples and oranges, but it is conceivable that an amateur who is cramped for space may do nearly as well with thirty 1/8-wavelength radials as an amateur with fifteen quarterwave radials.

Quarterwave radials on 80 take up a lot of room. My attic, only 30 by 70 feet, necessitated placing the 80-meter radials on top of the roof. The 80-meter radial system was connected to the transmission line and the 40-meter ground system by an additional number ten wire through the roof. Fortunately, during DX season on 80 the nights are long and the days short; so if you are clever with the deployment of radials, evening guests will never be aware of the conglomeration of wire hanging above their heads. My gracious wife allows me to lay out my radials anytime after we go off of daylight savings time!

80-meter sloped dipole

Dalton recommends using a 100-foot tower to support a sloping dipole cut for 3650 kHz. This configuration yields an included angle of 52° between the antenna and ground, which he says is optimum for DX. Unfortunately, my tower is only 70 feet, and by using the same scheme, the included angle would decrease to 33°, obviously unacceptable. Practicality dictated a compromise. I decreased the included angle from 52° to 45° and raised the resonant frequency to 3800 kHz. The length of the antenna now was 123 feet. I stretched 100 feet of it from the ground to the top of the tower (at a 45 degree angle) and dangled the remaining 23 feet down the side of the tower (secured at the 47-foot level). This array worked fine at 3800 kHz but the swr was very high 100 kHz from the resonant frequency. It is well known that the bandwidth characteristics of a folded dipole can be improved by placing shorting straps at a distance from the center of the dipole which is equal to the velocity factor of the twin lead times half the length of the dipole.[5] This worked out to be about 7.6 feet from the ends of the antenna on 3800 kHz. Using this configuration, the swr was 2.5 to 1 at the low edge of the band.

80-meter antenna comparison

Reports received from Europe and Oceania indicated that the ground plane has an edge over the sloped dipole although I noticed no difference on the receiving end. The sloping dipole may be equal to, or more effective than, the ground plane if it were erected correctly utilizing the 100-foot tower.

recommendations

If supporting structures of 100 feet are not available, try the ground plane for an effective DX antenna. If a 100-foot structure is available, try a sloping dipole first, since the erection effort is small compared with the effort expended in putting up a ground-plane radiator with its associated radial system.

Possibly neither configuration is feasible; if this is the case, the modified sloping dipole is preferred over an inverted vee at 60 feet or less.

If 40- and 80-meter DX capability is required and only space for one antenna is available, the 80-meter ground plane/40-meter 5/8-wave vertical will deliver the DX even if there is no room for 80-meter radials. If no 80-meter radials are used, loading against earth ground may improve results. This can be accomplished by running a number 6 or 8 wire from the common junction of the 40-meter radial system and the shield of the transmission line to the nearest earth ground.

references

1. Peter J. Dalton, K2RBT, "Antennas for 80 meter DX," *QST*, January, 1970, page 33.
2. "The ARRL Antenna Book," 9th edition, page 213, American Radio Relay League, Newington, Connecticut.
3. Paul H. Lee, "Vertical Antennas, Part I," *CQ*, June, 1968, page 22.
4. "The Radio Amateur's Handbook," 45th edition (1968), page 340, American Radio Relay League, Newington, Connecticut.
5. William I. Orr, W6SAI, "The Radio Handbook," 17th edition, page 440, Editors and Engineers, New Augusta, Indiana.

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