Making Tower-Mounted Half Slopers Work for You

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Amateur Radio, like most things in life, tends to follow trends. The current trend in station equipment typically involves factory-built transceivers, amplifiers and antennas. Today's amateur equipment has advanced to a high level of performance and sophistication. In fact, we have nearly reached the point where average hams cannot create anything of similar quality on their own.

There are many amateurs, however, who still possess that inner desire to create at least a portion of their station layout with their own two hands.

With this idea in mind, the station antenna system provides a great opportunity for creative experimentation and discovery without the need for elaborate and expensive test equipment. This is especially true for various types of wire antennas. Sooner or later, however, most amateurs feel the need to erect a tower.

The typical project will often include a tower, a triband beam or monobanders, and additional antennas for VHF and other bands. I occasionally work amateurs on 10, 15, or 20 meters who have towers and beams. When the discussion shifts to the topic of working the lower bands, I usually hear responses such as, "I don't work the lower frequency bands. I don't have room for larger antennas," or, "Yeah, I tried some slopers on my tower, but I couldn't get a decent SWR. It was a waste of time."

Despite such a pessimistic assessment, I can assure you that it *is* possible to create an all-band antenna system, on *one* tower, in a backyard situation. The result can be an antenna array that performs very well without adding a great deal of time and expense to a basic tower project.

The motivation to begin my own project came one spring evening about a year ago, when a tornado devastated my QTH. It totally destroyed my home and my antennas, creating the need to literally rebuild everything from the ground up. Despite the bleak task that confronted me, I realized that I could use the opportunity to correct some of the shortcomings in my original antenna layout. The result is a beam and half-sloper combination that provides very satisfying results to this day.

The Tower

Since I have been a ham for over forty years, enough time has passed to reduce my enthusiasm for climbing towers. Therefore, I chose a tower that permitted a ground-level work position. My requirements included

1) a tilt-over type design approximately 50 feet high with hand-crank operation,
2) multi-level guying capability,
3) a large poured-concrete base, and
4) a multiple ground-rod system with each rod driven deeply into the earth.

All of these requirements are fairly common considerations and were achieved with standard hardware construction techniques.

Guy Wires and Overall Tower Resonance

I deviated from the standard practice of breaking up guy wires with insulators. Actually, I did not place insulators in any of the guy wires. All of the guys make direct metal-to-metal contact at their attachment points with the tower *and* with the grounded guy anchors. This is an important step in lowering the natural resonant frequency of the tower to its lowest possible point. By enlarging the electrical size and cross section as much as possible, the tower, the beam and the guy wires combine to form a large vertical mass with its own resonant frequency. This is a crucial point to keep in mind when considering the use of tower-mounted half slopers.

As you physically view any tower, you are looking at a metal structure projecting above the earth. The bottom is usually grounded, making it the low-impedance end. As you progress up the tower, the impedance increases significantly. If you are about to install a half sloper and you select an operating frequency that is close to the resonant frequency of the tower, you will quickly discover that you can't feed it! The impedance mismatch is so bad, the low coax impedance (52 ohms) can't even begin to transfer power to the tower/sloper combination. The impedance on the tower is just too high. Small wonder that so many amateurs have had so much difficulty with tower-mounted half slopers!

It is a very frustrating experience to search endlessly for the resonant frequency of the half sloper you have just put up, unable to find a point where your pruning will drop the SWR to an acceptable value. The grim fact is, a high feed-point impedance creates a large SWR reading that masks any efforts to prune the sloper for a resonant frequency.

Obviously, low tower resonance is a *must* for successful operation of half sloper antennas. The benefits of this approach should become clear as we progress through the tune-up and usage of the slopers.

Other Advantages of Uninsulated Guy Wires

There are two other advantages of the uninsulated guy wire approach: It creates a large ground footprint which helps to dissipate direct lightning strikes, and it produces a large RF ground footprint which enhances the ground return of any antenna connected to the tower.

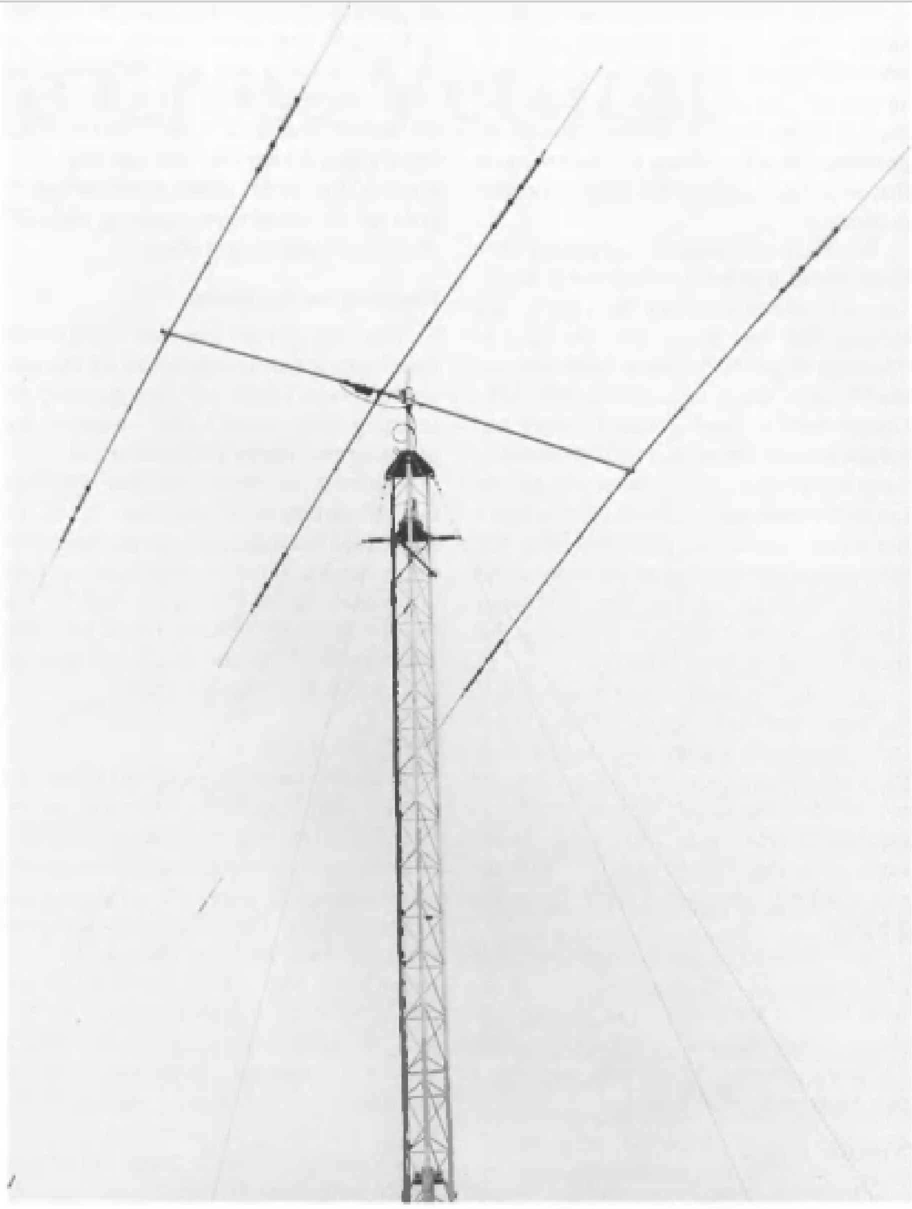

Fig 1—The upper half of the tower with guy lines and sloper wires visible.

A Word of Caution

The guy wires should be maintained in a reasonably taut condition. This insures that the metal-to-metal contact is constant, eliminating any noise that may result from loose connections. My installation is completely noise-free in this regard.

Antenna System Goals

The following criteria were established for the antennas on my tower:

1) the provision to operate on *all* HF bands from one tower,

2) coax feeds that do not require coils or traps,

3) survivability in severe weather and high wind conditions,

4) broadband operation without the need for a tuner,

5) good performance day and night, and

6) no additional towers or supporting masts required.

This is a fairly demanding list! However, with the successful installation of half slopers, all of the requirements were met.

Past Experience

Over the years, I have tried most of the HF antennas described in ***The ARRL Antenna Book***. The sloper type antenna usually gives better performance than horizontal dipoles and has demonstrated good DX ability as well.

The shortcomings of a sloping dipole have been evident at my QTH in terms of wind and weather survival. The sloping dipole has a hanging coax connected to its center. Not only does the coax whip around in the wind, but it is also subject to the stresses of ice loading. The result has been the frustration of watching the coax break off in the middle of a winter storm when it's not possible to do anything about it until good weather returns! The half sloper does not have this problem.

I would like to say at this point that a collection of half slopers is not the only antenna arrangement that will provide all-band performance on a single tower. A center-fed Zepp with a tuner would accomplish the same for many amateurs. However, considering the six goals I listed earlier, the half sloper is the best choice.

Putting It All Together

A half sloper is a ¼-λ wire fed with 52-ohm coax at the top end where it is attached, with an insulator, to the top of the tower. The braid of the coax is connected to the tower and the center conductor is connected to the sloping wire.

The length of any half sloper is computed using the standard quarter-wave antenna formula ($\ell_{ft} = 234/f_{MHz}$). I cut my slopers several inches long so that I could prune them down to the desired resonant frequency. This is a lot easier than soldering small lengths of wire onto a short sloper! I used RG8X mini-foam coax to feed the slopers. While I prefer the smaller diameter and greater flexibility of RG8X, RG8 is obviously the more durable coax.

I used stainless-steel hose clamps to secure the coax braids to the tower. I soldered the center conductors of the coax directly to the sloper wires. Be sure to use a good quality moisture sealant on the exposed coax opening around the braid and center conductor insulation. Twelve-gauge solid copper house wiring was used for the sloper wires. All insulators were made from 1½-inch schedule 40 PVC pipe.

Interaction...And A Bonus!

If you were to look down on my tower from a helicopter, it would look like a spoked wheel without a tire. The slopers and guy wires fan out around the entire tower (see Fig 1). The horizontal separation angles between adjacent slopers varies from 15° to 30°. The vertical slope of each wire is about 45° with the exception of the 160-meter antenna, which is long enough to require a much flatter angle. With this arrangement there is virtually no interaction between the slopers. There is one exception—that I use to my advantage!

It seems that most amateurs usually have to cope with the old problem of 75 versus 80 meters. After all, everyone wants an antenna that will work both ends of that band. A tuner could be used to alleviate the problem, but my goal was to create a layout that would *not* depend on a tuner to operate properly.

While the half slopers on my tower were fairly broad-banded, I shared the same 75- versus 80-meter dilemma. So, I put up *two* slopers, one for 75 and one for 80. The 75-meter sloper resonated at 3800 kHz and the 80-meter sloper resonated at 3580 kHz. Unfortunately, pruning either sloper had some effect on the other. I tried positioning them on opposite sides of the tower, but the interaction still existed. With a little experimentation I found that pruning the 80-meter antenna produced a greater effect on the 75-meter antenna than vice versa. That was when I made a discovery that turned out to be a real bonus.

With the 75-meter sloper connected to the transceiver, I *shorted* the 80-meter coax in the shack with a wire connected between the braid and the center conductor. As I did so, the 75-meter sloper jumped upward in resonant frequency to 3850 kHz. At the same time, the signals received from the east suddenly increased about 5 dB on the S meter.

My 75-meter sloper is on the east side of the tower. The 80-meter sloper is on the west side of the tower. The shorted 80-meter sloper became a *reflector* for the 75-meter antenna, effectively creating a two element vertical beam!

Another Bonus

Believe it or not, you can feed two or more half slopers with the same coax line. It's not a complicated procedure. Just tie the top ends of the slopers to the same coax center conductor. As of this writing, I have not tried to feed more than two slopers with one coax. Two slopers fed by one coax are best suited for a common feed when they are positioned next to each other.

I advise against trying to feed both the 75- and 80-meter slopers with the same coax. I tried it and soon realized that I was going through an endless and unsuccessful attempt to unscramble the interaction.

Interaction With Guy Wires

The guy wires appear to be neutral as far as any noticeable disturbance to nearby slopers. The guy wires at the top of the tower slope downward at about 25°. A sloper trailing away from the tower at 45° has a considerable distance developing between itself and the guy as the wires progress downward. This permits a sloper to be positioned within inches of a guy at the top of the tower with no noticeable effect. The bottom ends of all my slopers are tied off past the end insulators to metal fence posts driven into the soil. The locations of the metal posts were chosen to provide the direction, spacing and 45° slope angle mentioned above.

Planning for the Worst

The coaxial feed lines are taped to the tower legs at one-foot intervals all the way up the tower. This is my own standard for securing coax since I don't want to see *anything* moving in a 50-mi/h wind.

Midwest ice storms can take down all but the strongest of antennas. Even so, ice-loaded sloping wires are mechanically more durable and will survive better than horizontal wires. The strain load on the tower is generally downward and balanced with a reduced likelihood of tower damage from excessive sideload stress.

Tune-Up

Without exception, every one of my half slopers was resonated to the spot in the band I wanted, and produced a 1:1 SWR. A small amount of pruning was necessary on most bands to locate the optimum resonant frequency. The only serious deviation from the ¼-λ formula was on the 160-meter band. The 126-foot formula length proved to be too long for resonance at 1850 kHz. Since it was so near to the earth's surface, I suspected that the low fractional wavelength on the vertical position of this sloper was effectively lowering the resonant frequency. I had to prune off several feet to bring it on frequency.

SWR Measurements

All half slopers will produce a 1:1 SWR at their resonant frequencies. The bandwidths vary, with the 160, 80 and 75-meter slopers covering at least half of the band with a 1.5:1 SWR. The 40-meter sloper covers 200 kHz of the band with a 1.5:1 SWR. The higher frequency slopers cover their entire bands with a 1.5:1 SWR.

How Well Do They Work?

How well *do* they work? Very well—both day and night!

Half slopers are more or less vertically polarized, which is excellent for low-angle nighttime propagation. Some propagation experts suggest that vertically polarized signals are tilted off the vertical plane when they travel near the earth's surface. This tilt condition would help explain why all types of slopers perform so well. There also appears to be a very small amount of directivity in the direction of the slope.

I have made comparisons at my station between an 80-meter full-wave horizontal loop and a sloper. Daytime performance slightly favors the loop. At night, the sloper will be generally one to two S units better.

Band Coverage

As of this writing, I have erected tower-mounted half slopers for the following bands: 160, 80, 75, 40, 30 and 17 meters.

The 75- and 40-meter slopers are fed by the same coax, as are the 80- and 17-meter slopers. The 40-meter sloper has a low SWR on 15 meters and operates as a ¾-λ antenna on that band. I usually use my triband beam on 15 meters, so the choice is optional.

I have left one band out: 12 meters. In my case, 12 meters happens to be a band of low interest. However, it's just a matter of connecting one more wire to the array and choosing an existing sloper as its mate so that both can be fed from the same cable. I will probably connect it to the 80/17-meter pair, feeding three slopers with one coax.

Interaction from the Tribander Beam

Rotation of the tribander beam on the top of the tower does not have a significant effect on any of the slopers. I would expect a full-size 20-meter Yagi to produce some noticeable effects. Certainly a 40-meter Yagi would create a large overhang of overall tower mass that would influence the radiation angle significantly.

Other half-sloper users have reported that changes in sloper directivity become very noticeable when big Yagis are rotated. The difference between the ends of the Yagi elements hanging over the slopers versus the broadside portions of the elements in the same position appears to be the mechanism that varies performance. It can be readily seen that the angle of radiation would be modified in this case. Investigation of this phenomenon will probably be a future adventure at my QTH.

Conclusion

I have been using half slopers in the windy and turbulent midwest for eight years now. No other antenna has demonstrated their combined survivability and performance. It is a good feeling to look out the window on the morning after a big storm and see that the sloper farm is still in one piece. Give these half slopers a try on your tower. If you can keep the tornadoes away, you'll have the same satisfying view from your window too!