STAGGER STACKING

by BILL THOMPSON

Stacking antennas of the same kind can be of great use for improving weak signal DX results, especially with regard to tropo and meteor scatter work. Usually, this technique of combining the outputs of two antennas is used to sharpen their forward receiving patterns, making the antenna nulls extremely "deep," while producing a theoretical 3 dB increase in forward gain (actually closer to 2.5 dB in practice).

Deep antenna nulls are important to a DXer——perhaps more important than antenna gain in many cases. When you are trying to identify a DX signal through a local or semi—local groundwave signal on TV or FM, your chances for success often depend solely on the depth of your antenna's nulls. You have to get rid of the strong signal to pick out the weaker one underneath.

For this purpose, three general types of antenna stacks are popular with VHF DX enthusiasts, all of them for their own special characteristics. There's vertical stacking, with both antennas mounted on the same mast. Then there's the horizontal stack, with side—by—side mounted antennas. Finally, there's a combination of the two previous approaches, the quad stack, with four antennas——to produce the best characteristics of the vertical and horizontal configurations. The quad stack may well be the ultimate DX antenna system for the TV or FM enthusiast.

More elaborate arrays would consist of 8, 16, or more (I) antennas stacked, and are usually only found in CATV work. Actually, going beyond a quad stack array poses so many additional problems (combiner loss and phasing considerations start to get very critical) that it becomes not worthwhile.

A type of horizontal stacking, known as phase—nulling, has been used by some DXers with much success for DXing E—skip literally in the shadow of their local transmitters. Used mainly by TV DXers, but also of great potential to FM DXers, this type of horizontal array requires a fairly good amount of backyard space, or perhaps a large area of flat roof. Phase—nulling takes advantage of the fact that varying the distance between two horizontally stacked antennas can greatly narrow their result— tant beamwidth by a considerable ratio. It can transform the deepest part of the antenna's individual nulls from a few dB down to 20 dB or more down——enough to make nothing less than an astonishing difference if done properly. It can even be far more effective than using a vertically mounted antenna for "re—polarized" E—skip DX, a trick popular with some TV DXers for getting some IDs through local signals, which works to varying extents mainly because it reduces local signals by about 20 dB. Without such tricks, a locally occupied channel can be all but useless for DXing E—skip, and you may only be able to have "solid CCI" at best when the antenna is pointed at the DX. With phase nulling, the DX signal can be made to wipe out the local signal under the same conditions! Proper phase nulling often has the effect of making the local or strong semi—local signal appear as if it were suddenly 60 or 70 miles away.

STAGGER STACKING

•A most useful article on phase—nulling for TV DXing appeared in the VHF—UHF DIGEST in the December 1973 issue (available to members through the Reprint Service). In this column, part of Bob Cooper's classic TEK NOTES series, you can find just about everything you need to know about this ingenious method of reducing unwanted local and semi—local signals to identify DX. Although this method is complicated by the fact that the amount of separation between the two antennas is determined by the angular difference between the direction of the local station and that of the DX,. the article includes a table of spacing distances that can be applied in almost any situation.

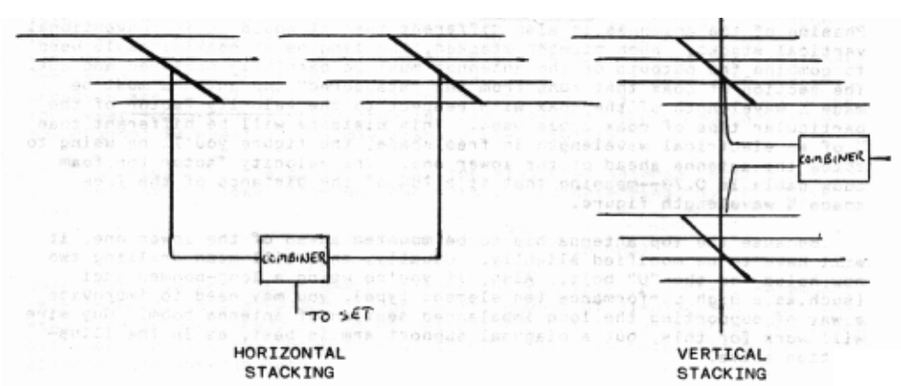
The real beauty of this method lies in the fact that for E—skip DX, antenna height is not especially critical——so such a stack need only be around ten feet, or slightly less, above ground. In fact, going much higher would probably hurt more than help, because you'd pick up more of the local signal, without a proportional increase in E—skip signal.

This method works because in addition to the 2.5 dB increase in gain, it more importantly produces a much deeper null pattern than would be possible with just one antenna. No matter how poor the null of an individual antenna is to start with, stacking another identical antenna side—by—side at a proper distance away (and with properly combined outputs) will produce a large improvement in the null. If you start with. decent antennas, the improvement is very large. For lowband E—skip on TV, five—element yagis are excellent in this application.

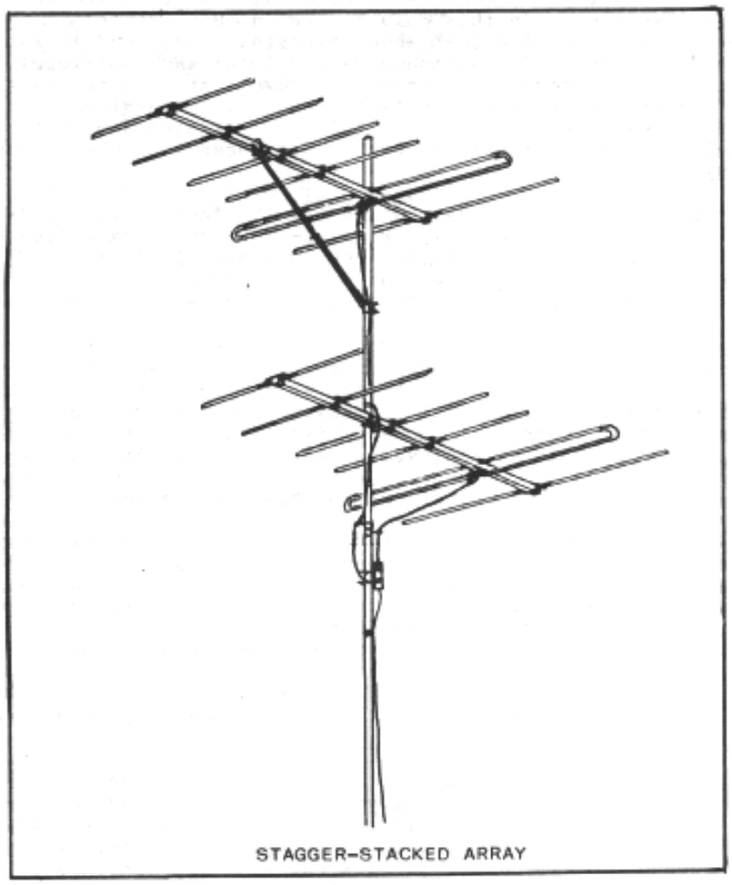
-s

Vertical stacking, on the other hand, is used primarily for the increased gain it brings——because it normally qives you no significant improvement in the depth of antenna nulls. It does bring a great improvement in the vertical plane pattern of the antennas, something that DXers usually do not concern themselves with. After all, it is the nulls in the horizontal plane that are most important to us. That's where all the DX is coming from! Nevertheless, stacking antennas vertically will always reduce signal fading, especially the type of fading usually encountered as "airplane flutter." It also substantially reduces E—skip fades.

But there is also a form of vertical stacking——a special variation of it——that can be used to great advantage to the TV and FM DXer$_6$ In cases where the unwanted local signal and the DX station are 180 apart in antenna heading, your chances to identify the DX successfully will normally depend upon the front—to—back ratio of your antenna. For example, a typical low band TV yagi offers about 20 dB of f/b ratio, meaning that the unwanted local signal would be reduced to about a tenth of the strength it would be if received from the front of the antenna. This may Sound impressive, but remember, a local station can flood your location with tens of thousands of microvolts of field strength——more than enough to produce snowfree video even within the deepest nulls of the antenna's response pattern. Clearly, when the DX and unwanted local signal are in directly opposite headings, the f/b ratio of a single antenna will not be enough, in many cases, to be of use; and horizontal phase nulling in this case is impractical.



STAGGER STACKING



STAGGER-STACKED ARRAY

So, in situations where the unwanted signal is directly in back of the DX——or, as we said, 180 apart in antenna heading——a technique called stagger stacking is the answer. The illustration above shows what a stagger—stacked array of two FM yagis looks like. As with conventional vertical stacking for gain purposes, proper antenna spacing is very important. And of course, both antennas have to be identical.

But with stagger stacking, one antenna——the top antenna——is staggered in that it is mounted *Z* electrical wavelength ahead of the lower one. Phasing of the antennas is also different than it would be in conventional vertical stacks. When stagger stacked, the lengths of coaxial cable used to combine the outputs of the antennas must be carefully measured and cut. The section of coax that runs from the "staggered" top antenna must be made Y_4 wavelength of the coax with respect to the velocity factor of the particular type of coax cable used. This distance will be different than *1/4* of an electrical wavelength in free space, the figure you'll be using to space the antenna ahead of the lower one. The velocity factor for foam coax cable is 0.78——meaning that it's 78% of the distance of the free space 1/4 wavelength figure.

Because the top antenna has to be mounted ahead of the lower one, it will have to be modified slightly. Usually, this will mean drilling two new holes for the "U" bolt. Also, if you're using a long—boomed yagi (such as a high performance ten element type), you may need to improvise a way of supporting the long imbalanced section of antenna boom. Guy wire will work for this, but a diagonal support arm is best, as in the illustration above.

STAGGER STACKING

Stagger stacking works the best only at one frequency. Therefore, this can only be done for one channel at a time. If you have more than one local signal that's directly in back of the direction of the DX, you can either build yourself another array, or make your stagger stack rig "flexible" in such a way that it can be quickly modified for the other channel. For E—skip on lowband TV channels, it's best to keep such an antenna stack fairly close to the ground——remember, going much higher will just tend to increase the unwanted local signal strength, and defeat your purpose.

The antennas you use have to be identical. Lowband yagis should be used if you have more than one lowband channels directly in back of the DX; for just one unwanted local signal, use a cut—to—channel yagi. The better the antennas you use, the better the results you can end up with. Stagger stacking two five—element cut—to—channel antennas with a fair amount of gain and a fairly good f/b ratio will give you about the same amount of gain a single ten element antenna would——but the resulting f/b ratio will be very good; much higher than possible normally. Those who have stagger stacked ten element yagis end up with almost incredible results, sometimes even reporting being able to see the tower lights of the local transmitter on the horizon in one direction, while the DX comes rolling in over the local from the opposite direction.

There's no magical secret to successful antenna phasing to create such deep nulls, although when properly done, you may think so. With horizontal phasing, and with stagger stacking, what you are doing is actually using the local signal to cancel itself out. In the case of stagger stacking, the local signal is arriving at the staggered antenna from the rear just a fraction of a second later than it's getting to the back of the lower antenna. After running through the unequal lengths of cable to the combiner, the signals from the two antennas combine in such a way that they are, electrically speaking, 180 out of phase. When the same signal combines with itself in such a way, it results in a net reduction in strength, rather than addition. In the meantime, signals coming from the other direction, 180 in beam heading away from the local, can only add together as they would in a conventional vertical stack.

In order to construct a stagger stacked antenna array properly, you will need to follow certain guidelines. First of all, make sure the vertical distance between the two antenna booms is at least 0.6 wavelength of the channel or frequency in concern. For best results at lowband, the vertical separation between the antennas should be one wavelength; however, this may not be possible at channel 2 for most DXers, as it would mean that the antennas be 17 feet apart. In this case, you may have to settle for 0.6 wavelength spacing (over 10 feet). Here are some suggested spacings to use for the vertical separations:

Channel	2	3	4	5	6	88.1	99.9	107.9
Vertical Separation (in.)	124	112	103	90	83	80	71	66

This distance can be found by dividing the frequency, in MHz into 11808 (to give you wavelength in inches), and multiplying the result by 0.6 (in other words, you are looking for 60% of the distance of the wavelength for the optimum spacing in inches). The figures given above for the TV channels are optimized for the center of the channels. Purists may argue that what you are most interested in eliminating is the video carrier of the channel in question, so may wish to re—calculate.

You must also find the distance that the staggered antenna "sticks out in front" of the lower antenna, and this can be determined by the formula:

1/4 wavelength (in MHz)= 2952/freq(Mhz)

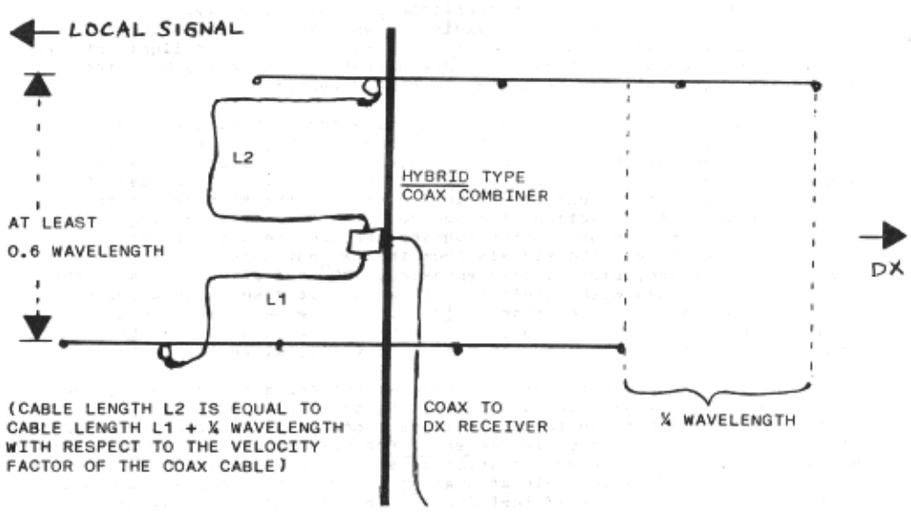
This will give you the amount of staggering distance in inches. Remember, this is equal to '4 wavelength, and is the amount of displacement that the staggered antenna leads the lower antenna by. It is, of course, the exact distance that you will have to know to drill the new holes for the "U" bolts on the antenna boom..

STAGGER STACKING

Here are some suggested staggering distances:

Channel	2	3	4	5	6	88.1	99.9	107.9
Stagg Dist(in)	52	47	43	37	35	34	30	27

Finally, pay careful attention to how you cut the lengths of coax that run to the combiner. As we said, they are unequal in length, unlike with regular vertical stacking designs. You must use a good quality foam coax, preferably a shielded—foil type. Refer to the diagram below, showing what such an array looks like from the side. Note that cable length LI can be any reasonable length, as long as you keep it so there's just enough to reach the combiner, running from the balun at the antenna feed point. L2 will be equal to the length of LI *plus* one quarter of the wavelength of the signal in the transmission line. Note that this length will not be the same as the one quarter wavelength distance in free space.



This figure will turn out to be ——as we noted earlier—— 78% of the distance of a quarter wave in free space.

Be sure to follow good stacking practices as detailed in previous VUD articles, notably the August 1976 issue. This means making sure the coax lengths are cut properly, using identical baluns on the antenna feeds, and also observing polarity of the baluns themselves, so that the signals combine properly. In fact, the combiner you use will be key to the success of the system. Make sure it's a hybrid type coaxial combiner (which allows the signals from the antennas only to add to each other in the proper way——with a high amount of isolation between inputs).

Antenna stacking is always tricky——many have been disappointed by the results because they compromised in the wrong place, or combined antenna outputs improperly. But when it's done right, the results are usually well worth the cost and effort to a DXer. With stagger stacking, you have a way to greatly reduce signal strength of unwanted stations directly in back of the DX. Study your locals closely; if one or more of them are coming from a direction that causes you to miss some good DX coming from a heading 180 degrees apart on the rotor dial, stagger stacking could well be of great use to you.

June 1982 VUD pp25-28