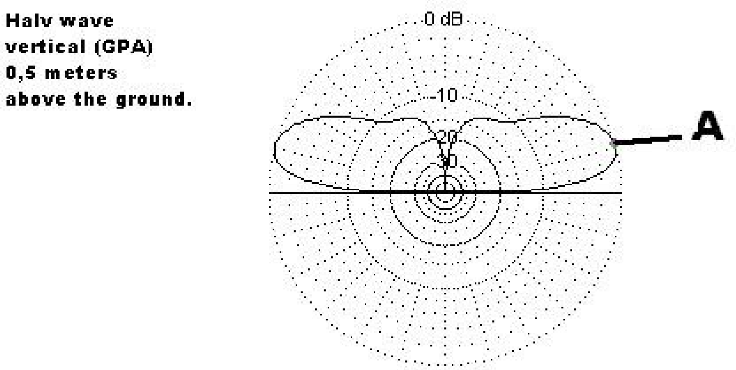
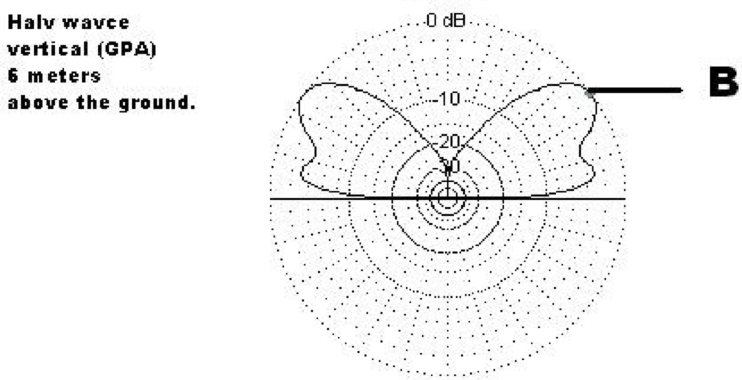
What's important for an antenna selection and installation

As there are always discussions about antennas this hopefully brings some technical background into it. Naturally the mechanical quality of an antenna is important too as no-one wants the antenna to break.....

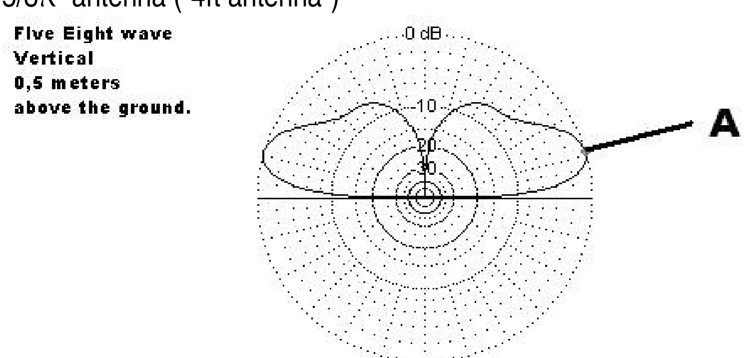
Antenna radiation patters for vertical antennas (side view). All antennas are non directional in horizontal direction which means they radiate the same amount into all directions.
First some radiation patterns normalized to maximum level.

Half wave dipol ("3ft antenna")

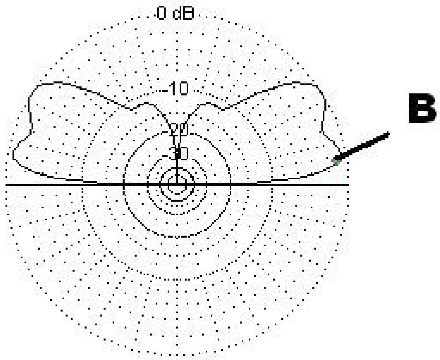




5/8λ antenna ("4ft antenna")



Five eight wave vertical 6 meters above the ground.



If you stack these antennas vertically you achieve higher gain by further compressing the lobe. This is done for the longer antennas. The typical “8ft antenna” is two 5/8λ antennas stacked with a matching in between.

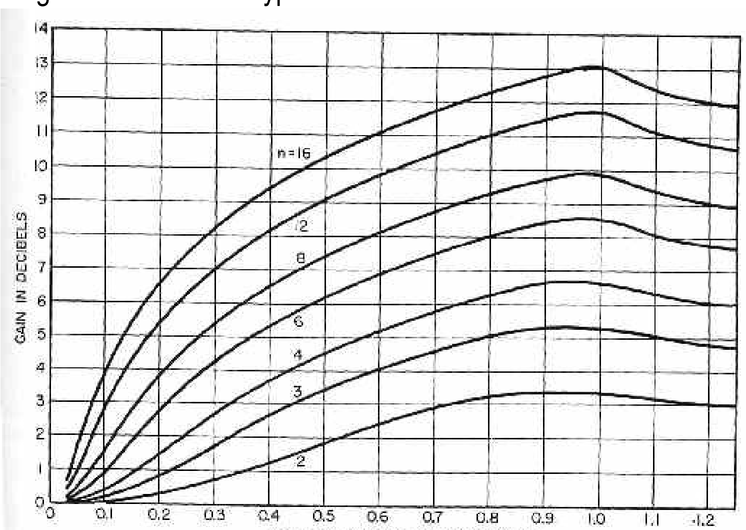
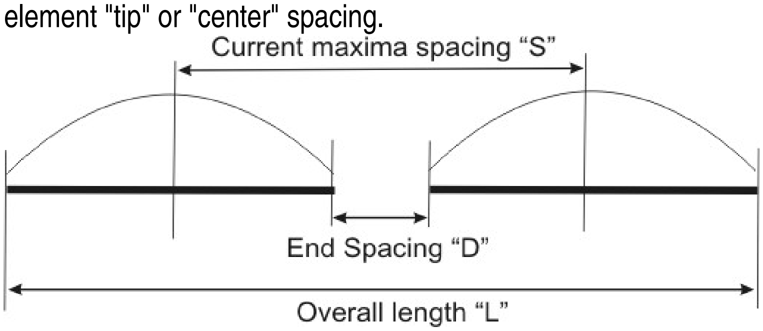


FIG. 5-22. Gains to be expected from a collinear (omnidirectional) array of short-dipole elements. The gain is relative to that of a single element.

The "Relative Spacing In Wavelengths" in the graph above is the ***current-maximum*** spacing of the elements, not element "tip" or "center" spacing.



With two dipoles placed end-to-end at the center with almost no end spacing, spacing of current maximums (S) would be .25+.25=.5λ. Overall length would be twice that of a single dipole, or 1λ. Maximum theoretical gain for this spacing is found on the graph above, at the crossing of the vertical 0.5 RELATIVE SPACING IN WAVELENGTHS and intersection of "curve 2" (the two-element curve), as just under 2dB over a single element. Gain would be less than 2dB over a single element in ANY collinear antenna using 1/2λ or shorter elements with very small element end spacings (D). Despite what is commonly claimed, doubling the number of elements and doubling array length does ***not*** increase gain 3 dB.

That's why they use two 5/8λ stacked elements in 8ft antennas as the 5/8λ already has a compressed pattern and stacking it gives a higher gain over 1/2λ dipoles (3ft antenna).

What's important to notice is that with a high gain antenna the pattern is well compressed and if the antenna gets out of the vertical position the achievable range in one direction may be very short as most of the energy is radiated into the water. That's even worse if one wants to communicate with a station which is installed on a higher elevation. On sailboats which quite often “hang in the wind” this is very critical and the reason they usually only use 3 or 4ft antennas on top of the mast.

The 25W power for marine VHF radios is plenty enough to establish a reliable communication link even with the smallest 3ft antenna. The range is simply limited by the line of sight and cut short by the Earth being a ball. What helps a lot more is to install the antenna as high as possible as that increases the possible line of sight distance. Here every foot counts and adds a lot of range.
As antenna elements are very sensitive to their environment (conductive or lossy materials) in many cases a “short” antenna on an extension mast which brings the tip to the same level as a “long” antenna would reach may give better results as the pattern won't be distorted and the available energy not “burned” in the hardware around it. The same can apply when the boat is rolling which could result in less field strength at the receiving station due to the fact that the maximum radiation would go above or below the receiving antenna (same in the other direction).
Mounting a shorter antenna on a long mast provides another advantage. The main radiation pattern is well above the crew and at 25W the field strength is already well beyond healthy values. It also gets the antenna out of the “noise” generated by electrical and electronics parts which significantly improves the received signal quality.
Another thing to consider is that a 3dB gain improvement will only get you sqrt(2) or 1.41 times more distance under the assumption that you have line of sight (which you won't have on water, see below).

One thing to consider with antennas is that the gain numbers quoted have to be taken with a grain of salt! If no reference is stated you have to assume against an isotropic radiator (which doesn't exist). That's the most common form to specify antenna gain. Unfortunately there are also some companies out there which claim fantasy numbers for gain. There are no miracle sauces in physics and no-one can improve the gain of a given mechanical system. You can only make it worse by using low conductivity metals or high absorption cover materials.......

For those interested in line of sight numbers there's a nice calculator here:
http://www.hamuniverse.com/lineofsightcalculator.html
Be aware that the number you get is the range one station has. If the second station is at the same height this value is doubled (see examples on that page).

Coverage range:
Let's do a bit of math to show how far you can get with a 160MHz link with dipole (1/2λ) antennas on both sides. Output power 25W or ~44dBm. Even a lousy receiver will give a good reception at 5uV @50 Ohms or -93dBm signal from the antenna (they are usually better). That means you can overcome a free space loss of 137dB which equals 2100km or 1305 miles! In real life that will be less due to additional losses from water (like in fog or clouds) or man-made noise but it shows that the 25W granted for marine use is really enough and you will never have the antenna heights to ever get there. This gives also plenty of room for additional losses in the antenna cables and connectors.
A free space loss calculator can be found here: http://www.radio-electronics.com/info/propagation/path-loss/free-space-formula-equation.php

Keep in mind that the Coast Guard uses directional antennas facing the area they cover with good gain and their receivers are high end and they don't have a 25W power limit. That gives you even more possible range!

There are conditions where a higher power or a high gain antenna may have an advantage. That's when you boat in canyons, rivers with curves and steep walls and in areas with a lot of forest around. With more radiated power in a certain direction you may get lucky and the signal reflected from hard objects may still be strong enough to reach the “other station”.

Happy boating and always the connectivity you want or need!

Jürgen