160 m. receiving antennas overview and evaluation.

by Pierluigi "Luis" Mansutti IV3PRK

On low bands, and particularly on 160 meters, it is important to have a separate receiving antenna from the one used for transmission. This is essential when transmitting with a vertical, which is defined as an antenna that "receives equally poorly in all directions". The characteristics and needs of transmitting and receiving antennas are not the same and therefore the parameters with which we evaluate their quality are different. Some, very important for transmission, such as efficiency and gain, absolutely do not translate into better reception which, on low bands, is always conditioned by noise outside the receiver. The basic parameter for an Rx antenna is not gain, but directivity. Gain is determined by efficiency, while directivity does not need it, and can also accept significant losses.

Nowadays, all receivers are very sensitive and can receive extremely low signals. The problem is not so much to increase the incoming signal by a few decibels, but to separate it from the noise that generally masks it. Thus, it is not the gain that interests us - and in fact the most basic trick on the low bands is always to reduce RF Gain - but the signal/noise ratio, or S/N - and this can only be done with the antenna.

The concept of RDF - Receiving Directivity Factory.

There are three types of signals that we can receive. The first is the specific signal that we want to listen to at that moment. The second type of signal is QRM, or interference from other stations near or far away, of which the direction and angle of origin can be determined. The third is NOISE, both of atmospheric and terrestrial origin, of undefined origin and angle, and which above 14 MHz is not a problem, but increases on the lower bands until it sometimes becomes prohibitive on 160 meters.

So, our need is not so much to increase the intensity of the signal we want to receive, if at the same time the underlying noise also increases, but rather to reduce the overall noise coming from all directions and make the desired signal emerge just enough to be able to "separate" it and thus improve the signal-to-noise ratio.

Recently, thanks to the great potential of programs like EZNEC, Tom W8JI (www.w8ji.com/) has introduced a new parameter to evaluate the performance of receiving antennas and establish a ranking, the R.D.F (Receiving Directivity Factor). This is nothing more than the difference between the maximum gain of the antenna in the direction we are interested in, and the average gain of the same antenna in all other directions. This average gain is the sum of all the gains calculated for each possible direction (from which the noise comes), divided by the number of these directions. To process a three-dimensional radiation pattern with a step of just one degree, the program calculates 64,800 directions; if we lower the step to 5 degrees, the calculation is reduced to 2,592 directions, with no significant difference in the results, but in any case, for the computer it is a matter of seconds.

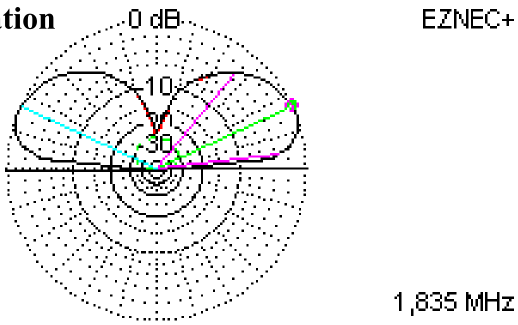
All receiving antennas have negative gain, but this is not a problem with modern receivers. We are dealing with very weak DX signals here, barely audible, and we need to raise the level just enough to separate them from the noise. Every dB of improvement in RDF means that, if we are trying to pick out a signal from the noise, all the other signals and noise, coming from different directions and at different angles, are reduced by 1 dB, and, even if 1 dB seems very small, at this level it is very significant.

For most receiving antennas, practical RDF values are under 10 dB. To achieve values of 12 or 13 dB, you need a lot of space (i.e. hectares of land). While there are excellent sites on the web dealing with the subject with a lot of tables and rankings: (www.w8ji.com/) (www.seed-solutions.com/gregordy) (www.k7tjr.com/), here I will limit myself to reporting only the practical cases of RDF calculation on some of my real antennas (extracted from a huge EZNEC analysis of my complex environment in a much detailed 26-page document, downloadable here: https://d.docs.live.net/0851f36be2efa81b/File%20per%20SuperSite/RXant.PRK_160m.INTERACTIONS.pdf) or directly from my website.

My Tx vertical antenna – Shunt Fed Tower.

The radiation patterns of the vertical antenna are classic, with the elevation angle at 25 degrees, ideal for DX on 160 m., and the positive gain of 1.3 dB, therefore with the efficiency necessary for transmission. The horizontal radiation pattern is perfectly circular, which means that the antenna radiates well everywhere, but also receives "equally badly from all directions".

Elevation



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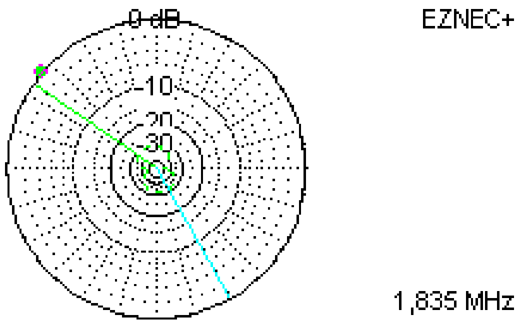


The radiation resistance is about 32 ohms and the inductive reactance of about 35 ohms (first row of the table below) is compensated by the capacitance inserted in the gamma match.

			Gain	TO angle	Avg. gain	**RDF**	Source Resistance	Source Reactance	
Tower-4			1,30 dB	25°	- 3,76	**5,06**	31,80	+34,84	4 ¼ wave elevated radials
Tower-32			1,73 dB	25°	- 3,34	**5,07**	34,95	+47,78	32 ¼ wave on ground radials

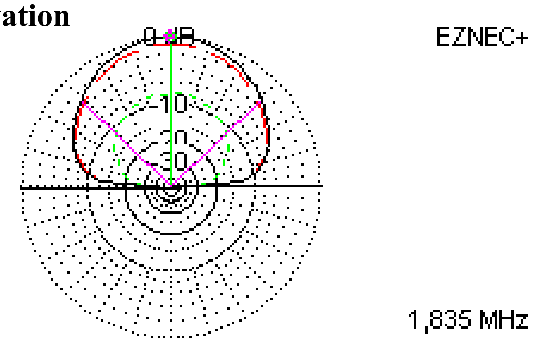
Wanting to increase the ground system and go from the 4 elevated radials (Tower-4) as they are in reality, to 32 ground radials (Tower-32) would improve the efficiency and gain by 0.4 dB but, as far as reception is concerned, there would be no advantage. The RDF remains very low as the directivity is not modified, confirming that reception is absolutely independent of the ground system and the efficiency of the antenna.

The low dipole.

The low dipole - or rather very low - is instead a classic case of poor efficiency. It resonates perfectly at 1,830 KHz, but the negative gain indicates the presence of prohibitive losses in transmission, even if the standing wave curve appears ideal. However, it can give the impression of working well in reception and constitute a useful alternative to other antennas, provided that it is kept well away from them. It requires a lot of space, and I had to eliminate it, as it was too bad interfering, and compromised the operation of nearby antennas.

Being too close to the ground, it loses every kind of directivity, but the RDF is better than that of a vertical antenna because, rather than receiving "equally badly" from all directions at large low angles, the low dipole receives "equally badly", but from a more limited area and at very high angles towards 90 degrees. Much of the noise and QRM that propagates at lower angles is greatly reduced, and the ability to receive a signal at high angles can be useful, beyond local contacts, even for DX on rare occasions, usually at dawn or dusk.

Elevation



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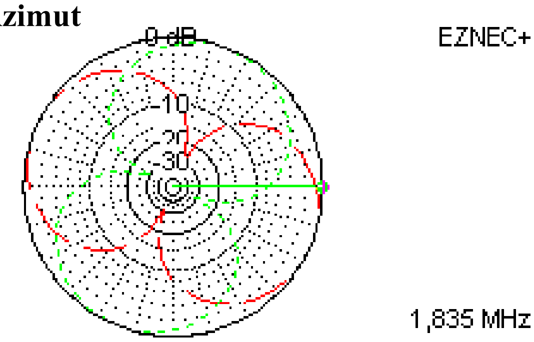


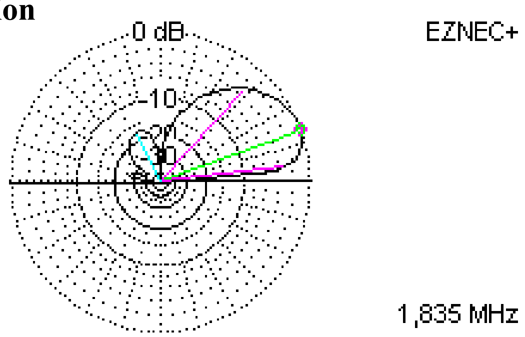
			Gain	TO angle	Avg.gain	**RDF**	Source Resistance	Source Reactance
Low dipole			- 2,70 dB	90°	- 10,00	**7,30**	50,42	1,12

The receiving "Four Square Mini-Phased Array".

Built in 1994, it has been my best receiving antenna for ten years, and did not need any alternatives. It consisted of 4 vertical dipoles 10 meters high, loaded at the center with ferrites and arranged on a square of 13 m. per side and fed all together with very critical phase shifts. It was a very complex matter with the use of several toroids, but it was worth it. The results were excellent, with one flaw: the dependence on weather conditions and soil humidity which, by varying a resistive component, unbalanced the precision of the phase shifts.

These are the vertical and horizontal radiation patterns, with an ideal angle of 20 degrees and a front/back ratio of 30 dB. The output signal is sufficient (just 6 dB negative) and does not need a preamplifier. Above all, an RDF greater than 9 dB.

Elevation



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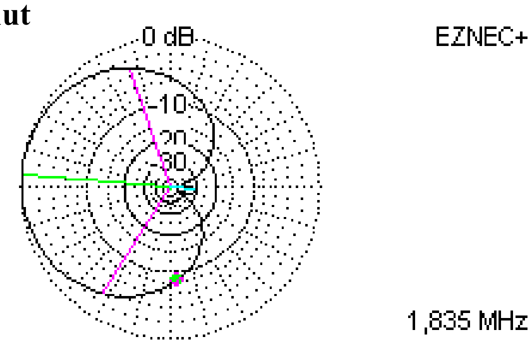
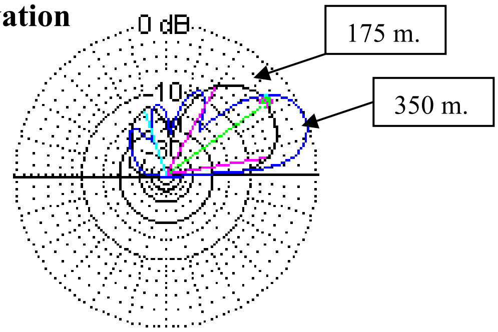


	Gain	TO angle	BW	F/B	Avg.gain	**RDF**
4-square	- 5,86 dB	20°	127°	30 dB	- 15,23	**9,37**

The Beverage antenna.

Without any doubt, the Beverage remains the most classic and best antenna for low band reception. It is simple, easy to build and set up, very cheap but… it needs a lot of space. Those who have at least ten hectares of land, far from residential areas and free from power lines, can lay out several of them and have no need for other solutions. The ideal length of the Beverage for 160 m. is 175 meters (to obtain the so-called "cone of silence"), and 350 meters are even better, but the lobe (BW) narrows, and the number must be increased to cover all directions. It is a truly directional antenna and therefore the RDF reaches very high values.

Elevation



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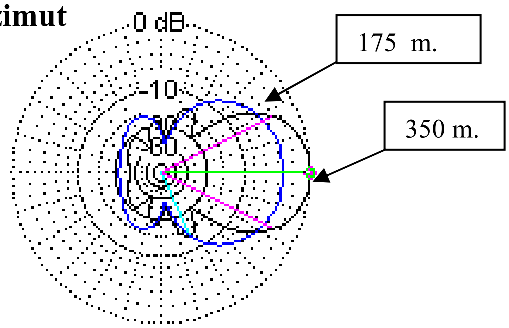


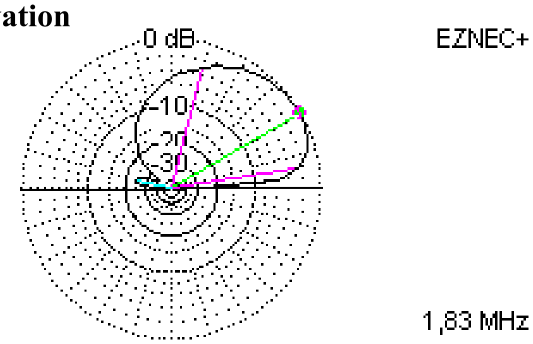
			Gain	TO angle	BW	F/B	Avg.gain	**RDF**
Beverage 175 m.			- 9,82 dB	36°	84°	18 dB	- 20,63	**10,81**
Beverage 350 m			- 6,43 dB	24°	53°	27 dB	- 20,09	**13,66**

In any case, already with 80/90 meters of length you can get satisfactory results, but in this case, comparable to those of the different types of loops that all have a much wider lobe.

Pennants and Flags.

These are closed loops of small dimensions (about 9 meters per side by 4 in height) closed by a resistance of about 900 ohms on one side and by a toroidal transformer at the feed point on the opposite side. Their operation is based on the principle of two small end-fire verticals fed through the horizontal wires, like the Ewe and the K9AY loop, but the feature that makes me prefer them is their "independence" from the ground, to which there is no connection.

Elevation



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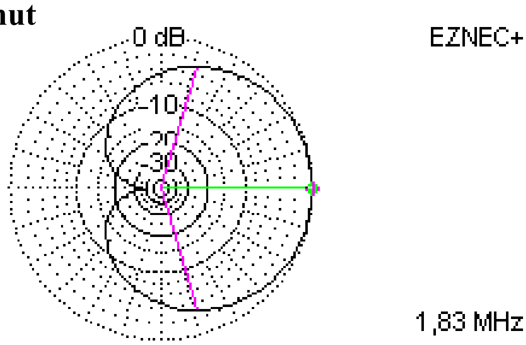

File			Gain	TO angle	BW	F/B	Avg.gain	**RDF**
Pennant			- 35,32 dB	30°	147°	37 dB	- 43,11	**7,79**

The resulting lobe is a very wide cardioid with a very good front/back ratio, although the RDF is not exceptional. The output signal is very low, but with one or two good preamps there is no problem.

I currently use eight Pennants, six of them in groups of three, with 90 meters separation and, and fed in broadside and end-fire combinations. Belonging to the same family, is a rotary Flag that, placed on a small tower, passes the power line and is, in 90% of cases, my best receiving antenna.

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