Eliminating Ghosts

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Eliminating ghosts was first published in Television *magazine in Nov 1978. 'Ghosting' is the reception fault in which a second image appears on the screen, to the right of the main one. The article is mainly concerned with the use of stacked and phased pairs of UHF aerials to achieve good directional properties.*

Fortunate indeed is the aerial contractor who operates where good, strong signals abound. But pity the poor soul who has to live with good, strong ghosting as well. Ghosting, as all customers know, is something that can be cured by any half-competent aerial man in next to no time and at minimal cost. 'The man who mended the telly said the aerial just needed moving round a bit to get rid of the ghosting.' The service engineers who cover our patch seem fond of such unguarded statements! The truth, unfortunately, is often sadly different. Faced with a really good aerial installation which is nevertheless producing very ghosty pictures, the aerial contractor is very much aware that things aren't as simple as the customer (and the tv engineer!) sometimes seems to believe.

As aerial contractors in an area of generally high field strengths but often very bad ghosting, we've been much involved with the 'ghost problem' over the years. In the early days of uhf transmissions most of the major aerial manufacturers produced stacked arrays. These were supposedly the ultimate answer to ghosting. In practice however results were variable. No improvement at one call; a pleasant surprise at the next; and so on. The whole thing had an alarming air of unpredictability, while the time and trouble involved in each installation meant that a high failure rate was quite unacceptable.

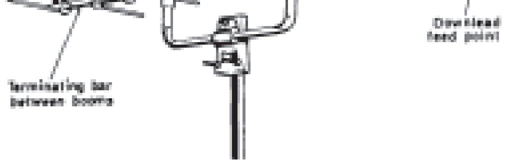

Fig. 1. The Jaybeam LBM2 log-periodic aerial

Log-periodic Aerials

The manufacturers' next bright idea was in the shape of the log-periodic aerial. And a very peculiar shape we thought it to be (see Fig. 1). Log-periodic aerials are enigmatic, inscrutable devices. They are quite unlike more familiar aerials in that every element is driven. In other words there are no reflectors or directors, but simply a series of dipoles which are connected to the downlead via the boom. In fact there are two parallel booms. Each dipole is connected at its centre point across the two booms, and the polarity of this arrangement alternates along the boom. The ends of the booms farthest from the transmitter are shorted together, whilst the downlead is connected across the front end. Don't be misled by the appearance of the Antiference TS21: the coaxial feeder emerges from the back end of the aerial but runs along inside the boom to the connection point at the front. Log-periodic aerials generally have a characteristic impedance about 100Ω, but matching devices are not considered necessary. The coaxial inner is connected to the uppermost boom, and the outer to the lower one.

The 'spread' of dipole lengths from smallest to largest determines the aerial's bandwidth and, since the gain suffers little if this spread is relatively great, log-periodic aerials designed for domestic tv reception usually cover the whole of the relevant band, be it channels 6 to 13 or 21 to 68. If the gain is plotted against frequency (within the designed bandwidth) the result is a surprisingly straight line.

This flat response is one outstanding characteristic of the log-periodic aerial. The other is its extremely clean and sharp polar response pattern (see Fig. 2): undesirable rear and side lobes are smaller than those of a conventional aerial of comparable size. This is because the phase relationship between the

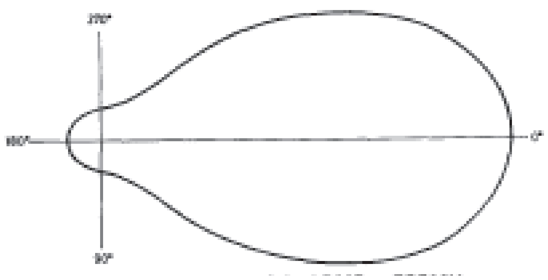

Fig. 2. Polar response of the LBM2 at 500MHz

voltages developed across each dipole (as they appear at the downlead having travelled various distances along the booms) tends to favour signals arriving from the front of the aerial rather than those arriving from any other direction. The lack of parasitic elements also helps to keep the response clean.

A highly directional aerial immediately suggests itself for anti-ghosting work of course, and the log-periodic aerial begins to sound ideal. The drawback is its poor forward gain, which seems to be an unavoidable feature of aerials based on this principle. The forward gain figure usually quoted is 8.5dB, which is significantly lower than a conventional 10-element Yagi aerial's gain of about 11dB. In many locations the poor gain of the log-periodic aerial effectively disqualifies it from anti-ghosting work, which is a great pity.

Some time ago Antiference produced a version of their 21-element log-periodic aerial with an amplifier attached. This alleviated the problem to a limited extent, but the cost of this product compared very unfavourably with that of a straight 18-element Yagi aerial without amplification and the results often didn't in the customer's eyes justify the extra expense. Antiference no longer produce a log-periodic aerial for ordinary domestic use: possibly they feel that their XG8, XG14 and XG21 aerials provide a more useful combination of gain and directivity.

Log-periodic aerials are nevertheless nice, light, compact arrays with low wind resistance, and in some locations the extra height that this allows, combined with the aerial's directional properties, will do the trick.

We've used a great many log-periodic aerials over the years to combat ghosting, but we very soon became aware that they don't produce the complete answer in every case. They were found to be at their best in areas of high field strength where, with say a combination of half a dozen factory chimneys to the rear and some local obstruction to the fore, strong multiple images are present on the screen. In this sort of place a ten or eighteen element Yagi would produce unrecognisable and unlockable images but a log-periodic aerial might, if it was your lucky day, give watchable but still very ghosty results. The fact that the customer would then appear to be unable to detect any improvement is neither here nor there.

The majority of our ghosting problems are not of this sort, however. Often the problem is one solitary ghost image which can be strong enough to make the picture unwatchable. Forty-four footballers controlled by two referees…video in stereo… In these conditions log-periodic aerials seem as unpredictable as the earlier stacked arrays. Unpredictable except that they tend to be at their least effective on the roofs of the most critical customers, just like all other aerials. Log-periodic aerials are cheaper than stacked arrays—if you can manage without an amplifier. They are quicker to assemble. Perhaps they work on average a little bit better. But they don't really solve the problem.

Back to the drawing board

So we started to experiment extensively, and spent a lot of time working with stacked arrays. We needed to tailor the response pattern of the array at each location to reject signals from one specific direction, that of the ghosting. At the same time, maximum forward gain must be maintained. This is important because the strength of the ghost image as it appears on the screen is dictated not by the strength of the ghost signal in absolute terms but by the ratio between it and the signal received from the transmitter.

In the early days we had simply fixed two aerials together and rotated the whole assembly for the best results. This was a bit hit and miss. A typical polar response diagram for a horizontally stacked array of two aerials is shown in Fig. 3. Ghosting from directions A1 and A2 will be

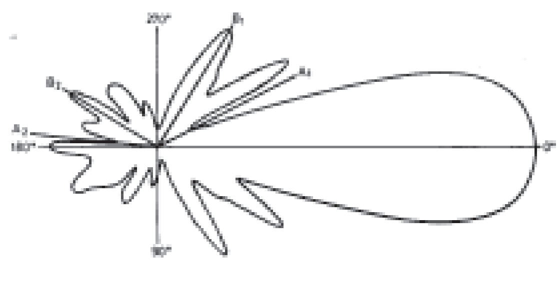

Fig. 3. Polar diagram of a stacked Yagi aerial array

largely rejected by the array, but ghosting from directions B1 and B2 will be rejected to a much lesser extent. We can't move the factory chimney, gasometer, or other reflecting object, so we must alter the angles of minimum and maximum signal acceptance. We must do this while still keeping the largest forward lobe pointing at the transmitter.

How? Consideration of the way stacked arrays achieve their directional characteristics lead us to realise that we have to satisfy the following conditions: (1) Both aerials must receive as much signal as possible direct from the transmitter, and these signals must be combined exactly in phase. (2) The ghost signals received by the two aerials must be of equal amplitude and must be combined exactly out of phase.

Alignment procedure

If there's only one really troublesome ghost signal to deal with, the above conditions can be satisfied quickly and easily as follows.
Fix a horizontal boom on a vertical mast (see Fig. 4) with an 18-element aerial at one end of

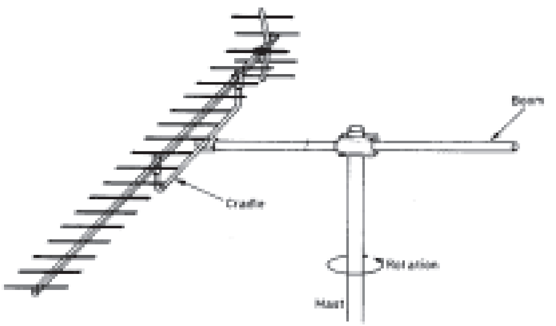

Fig. 4. Aligning the first aerial

the boom. The aerial's supporting cradle should be roughly central on the boom. Rotate this assembly for maximum signal strength, using a field strength meter or a portable tv set with an attenuator. Ignore ghosting at this stage. The boom should now be at right-angles to the direction of the transmitter. Secure the assembly in this position.

Connect this aerial and an identical one to the meter or tv set, using a phasing harness. Holding the second aerial in position along the boom, move it towards and away from the transmitter (see Fig. 5), carefully keeping it pointed at the transmitter. Since this movement alters the phase relationship of the two aerials, a maximum and minimum meter indication will occur. If a meter is not available and a tv set has to be used, the effect is visible but less obvious. Obtain a maximum reading, then mark on the cradle with

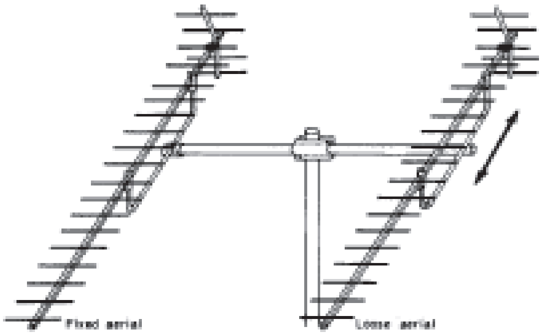

Fig. 5. Movement of the second aerial towards and away from the transmitter, for correct phasing of the signals received by both aerials direct from the transmitter. Adjust for maximum signal pickup. The phasing harness used when adjusting the aerials consists of a quarter wavelength of 50Ω coaxial lead connected between the 75Ω downlead and the equal-length 75Ω leads from the two aerials.

felt pen the point where it crosses the boom. Again, ignore ghosting. Repeat this procedure several times, with the loose aerial at different distances from the fixed one. The same mark on the cradle should coincide with a maximum meter reading at all points along the boom. If not, the boom is not at right-angles to the transmitter direction. Realign it if this is the case.

You can now alter the distance between the two aerials while they remain exactly in phase. In this way the forward gain of the combined array is always at maximum. The mark on the cradle must always be kept exactly on the boom of course. Don't be tempted to skimp on the adjustments leading up to this point: if there's a phase error between the two aerials at any point along the boom there will be a reduction of forward gain if the loose aerial is mounted at that point. This will make nonsense of any subsequent attempts at alignment for minimum ghosting.

With the two aerials still connected together via the phasing harness, next move the loose aerial sideways (see Fig. 6), observing the results on the tv set. It should be possible to identify a series of points along the boom where the loose aerial should be fixed for the two aerials together to produce minimum ghosting. At these points the ghost signals from the two aerials are exactly out of phase with each other. This happy condition will recur every time the loose aerial is moved through one wavelength towards or away from the source of the ghosting. If the ghosting is only slight it may be easier to find the points along the boom where the ghost is most visible: mark these, then mount the aerial mid-way between them.

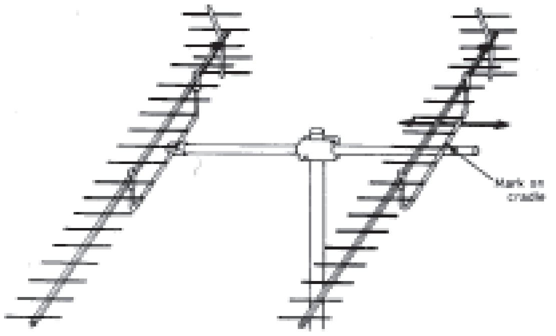

Fig. 6. Sideways movement of the second aerial. This adjustment is made so that the ghost signal pickup by the two aerials cancels out.

If the source of the ghosting is at right-angles to the transmitter direction, the points of minimum ghosting will be at one wavelength intervals along the boom. In fact the distance between the two aerials will be λ (n + ½). In cases where the ghost signal comes from an angle other than 90° or 270° the optimum positions will be more widely spaced. If the ghosting originates from almost exactly the same direction as the transmitter, or from almost exactly the opposite direction, the two aerials will need to be very far apart for phase cancellation to occur. In fact if the ghosting originates 5° from the transmitter axis (that is, from 5°, 175°, 185° or 355°), the two aerials will need to be about 140cm apart for channel group A.

Those of a mathematical bent will realise that the distance along the boom between the two arrays can be derived from the wavelength (λ) and the angle between the transmitter and ghost directions (q). The formula is λ (n + ½) sin θ.

Being more nimble on a roof than with a calculator we usually proceed by trial and error. The mathematical approach can help when there are two strong ghost signals from different directions however. The series of possible inter-aerial distances for each can be worked out, and a position for the second aerial chosen which approximates to one value for both. This should be regarded as a starting point for practical experiment however, not as a definitive answer. The easiest way to find the necessary angle for the calculation is to use a large-scale Ordnance Survey map and a protractor. The direction of the source of ghosting can be found by rotating the aerial whilst observing the tv screen. There is seldom any problem here, since the highly reflective culprit can usually be seen clearly on the skyline. In the highly unlikely event of the ghosting coming from exactly 180°, no phase cancellation would be possible and the ghosting would triumph. Fortunately this remains for us a hypothetical case.

Final adjustments

Because the final adjustments are extremely critical, and involve moving a fairly large aerial accurately through small distances, great care should be taken. It's impossible to eliminate ghosting if it can't be seen properly in the first place, so the right sort of programme must be on the air. If you find yourself trying to do this job with a rapidly changing selection of cluttered shots on the screen, well, go down the ladder and have a cuppa, and admire the customer's new microwave oven for a bit. This problem brings the writer dangerously close to his number one hobby horse, which concerns the lack of BBC2 test transmissions for most of the working day. 'Nuff said!

If the ghosting cannot be eliminated completely the reason may be that the ghost signals received by the two aerials are not of equal amplitude. If one aerial appears to be screening the other in this respect they can be mounted at different heights by simply inverting one cradle. The aerial itself should remain the same way up of course. Remember that it isn't essential for the two aerials to receive exactly the same amount of signal direct from the transmitter (although this is usually the case): it's the ghost signals that need to be exactly equal.

When a satisfactory picture has been obtained it will probably be found that the two aerials are at different distances from the mast. You can't move the mast sideways because it's attached to the chimney, but fortunately the two aerials and the boom can be moved sideways without the previous critical adjustments being invalidated. The distance between the two aerials must be kept exactly the same of course, so it's usually easiest to keep them clamped to the boom and move the whole thing in one piece. Check orientation by visual sighting along one aerial before and after moving.

Bandwidth requirements

In theory the correct inter-aerial spacing for one channel will not be correct for the other two. In practice this doesn't seem to be a problem. We usually carry out the alignment procedure on the most ghosty channel of the three or on the middle one. Minor adjustments can then be made if necessary after the pictures have been scrutinised. Reducing the distance between the aerials will favour the higher channels and vice versa. These adjustments are small: the theoretically correct positions for each channel maybe only 2-3cm apart if the two aerials are reasonably close together. This makes it easier to find a position which works on all channels however, and for this reason the two aerials should not be mounted unnecessarily far apart. We usually start with the aerials about one wavelength apart, and use the first optimum position greater than this distance.

Connecting the aerials together

An ordinary splitter can be used to connect the aerials together. Both inductive and resistive types are suitable. The split must be exactly equal, otherwise complete cancellation of the ghost signals will be impossible. Commercially available splitters are generally satisfactory in this respect, but a check can be performed quickly with the field strength meter. Connect the common terminal of the splitter to a signal source, and measure each output. The other output should have a dummy load connected.

We use splitters for this purpose because they give us an accurate impedance match in a simple and straightforward way. We haven't worried much about phasing arrangements, which might give better gain, because we are rarely troubled in our area by weak signal problems. With an ordinary resistive splitter the gain, as you might expect, is about the same as the equivalent single aerial. Those who wish to experiment with phasing harnesses of greater efficiency are referred to Nick Lyon's article on 'Removing Ghosts' (March 1978) and to 'Long-Distance Television' (March 1977).

Don't be tempted to connect the two feeders to the downlead without any impedance correcting device. The resulting mismatch will cause all sorts of unpredictable results.

The two feeders which take the signal from the aerials to the splitter should be of exactly the same length. If not it will still be possible to carry out the alignment procedure but one aerial will end up slightly forward of the other, which looks odd. There is also the possibility of unbalanced standing waves or some other inequality affecting the overall performance.

Choice of aerial

The two aerials must of course be identical. After some experimentation we now always use Antiference 18-element aerials for the job. When used singly these aerials seem to us to be as directional as any on the market within the price range. We have not used large, high-gain aerials in the stacked mode—as already mentioned, we have few field strength problems to contend with. The cost of two XG21s might also have something to do with it! We can see no reason why these very large aerials should not be efficient when used in this way, though they would need a well thought out mounting and stacking arrangement. We've removed many a nasty ghost simply by replacing the existing cheap 18-element aerial with an Antiference TC18 incidentally.

Co-channel interference

From the aerial rigger's point of view co-channel interference presents exactly the same problem as ghosting: how to achieve maximum gain in one direction with minimum gain in another. Stacked arrays can do a really good job here, because the signal rejection is usually required on only one channel of the three. Alignment can thus be carried out on this channel, with no need to worry about the others. Co-channel interference disappears in a much more definite and obvious way than ghosting when the final adjustments are made, so finding the exact position along the boom for the second array is that much easier.

Mounting the array

Rigid mounting is essential if the results are to be reliable. The mast should be of 1½ or 2in diameter, with a 12in chimney bracket or the equivalent wall bracket. A 6ft x 1in heavy gauge mast is ideal for the boom, which should be cut to length when all adjustments have been made. The feeders should be brought away from the aerials as neatly and cleanly as possible, and in an identical manner on both sides of the array.

As already stated, the technique depends for its success on each array receiving an identically strong ghost signal. For this reason the field strength of the ghost signal must be uniform over the area of the array. When considering where to mount the array therefore, keep it away from other aerials or anything else that might obscure or reflect the signal.

With a single aerial, it's often possible to find a place for the installation where the ghost signal is attenuated by intervening brickwork, stone or trees. Unfortunately this normally useful wheeze doesn't combine well with the use of stacked arrays, presumably because the ghost signal is of an uneven and irregular nature in such a location. Stacked arrays seem to be happiest nice and high and as far away from other objects as possible.