Trees and UHF reception

Bill Wright

from *Television*, May-June 1990

All engineers involved with UHF reception are aware that trees can cause problems. This article describes some of the interference mechanisms that commonly occur and suggests techniques which might help to overcome or at least alleviate poor reception.

Part 1, May 1990

Trees can do lots of nasty things to your customers' tv pictures, and they can do them in lots of different ways. Trees can suddenly and unaccountably have a severe effect on reception that's been perfect for many years. They can affect one channel to the point of eliminating it whilst having no effect on the others. They can affect sound but not vision. Reception can vary seasonally, daily or by the second. A tree doesn't have to be between the receiving aerial and the transmitter to cause trouble: clear line-of-sight reception can be affected by nearby trees.

Basic rules

The basic rules of aerial rigging should be applied, only more so, when an aerial installation is to be undertaken at a location where signal disturbance from trees is expected. Use a good quality aerial. Approaching the job with a £1.50 10-element aerial is a waste of time. A good quality 18-element array such as the Antiference TC18 has excellent directional characteristics, good performance even at the ends of the channel group and accurate impedance matching. These factors can make a lot of difference where tree problems are involved. Unless signal strength is a problem there's no point in using a very large, high-gain array. Its lack of manoeuvrability could be a positive disadvantage in fact. Don't use a wideband Yagi: the poor forward gain and directivity make it unsuitable. If a high-gain masthead amplifier is required, use a group rather than a wideband model.

Modes of interference

Trees affect reception in a number of completely different ways. It's vital to understand the modes of interference when attempting a cure. Those described in the following sections are classified by the position and density of the trees, but it must be borne in mind that each section is a broad generalisation and that in a real-life situation the categories often overlap. Signal attenuation through trees tends to increase with frequency, so more extreme effects will occur in Band V, especially at the top end, than in Band IV.

Distant dense woodland

We'll consider first a large area of dense woodland distant from the receiving site but obscuring the signal path. In a typical case there might be a substantial tall deciduous or coniferous woodland across the skyline on high ground 2-6km in front of the aerial. Topography rules out the possibility of obtaining line-of-sight reception over the trees, but it's the trees that cause the obstruction, not the hillside. In summer or winter no light through the trees at the receiving site.

Surprisingly this is usually quite an easy tree problem as tree problems go. If the trees are deciduous, the signal level is likely to be 10-25dB below the calculated line-of-sight figure in winter, falling to as much as 30 or even 40dB below the line-of-sight figure during a typical midsummer's day when the trees are in full leaf and wet from heavy rain. Path loss will vary between channels, but usually by not more than 10dB across a standard channel group. Daily variation seldom exceeds 10dB. Rapid signal fluctuation is unlikely.

If the line-of-sight signal is +20dB/mV or better the signal is likely to be a usable -10dB/mV or better for almost all the time but with occasional dips to -20dB/mV, which will result in noisy pictures no matter what amplification is used. I should mention at this point that all signal strengths quoted in this article are those obtained using a good 18-element array. This is not the true field strength as measured in dB/mV/metre, but is far more useful for our purposes.

There are unlikely to be enormous field strength variations from one location to another on the roof, but it's worth checking all possibilities. If the aerial can be installed anywhere on a large building or complex it's worth meter-checking the signal at a good selection of possible locations since significant variations can occur over distances of 25m or more, even where a survey confined to a smaller area seems pessimistic. If a peak occurs it will be consistent as the test aerial is moved directly towards or away from the transmitter. This might help in finding a permanent position.

Aerial height is unlikely to have a dramatic effect on signal strength. There may be a gradual improvement with height or there may not. There may be a slight peak, which could be at any height. In a difficult case it's worth checking with a meter from ground level up to the maximum practical height. If a peak is found it won't be very great or very well defined, but it might yield an extra 4-6dB, which can be very useful when you're struggling.

Where the required transmitter gives only a moderate signal level in the district a location behind trees may prove to be impossible on field strength grounds alone. Even within the nominal primary service area, the field strength behind distance dense tree cover of this kind is likely to be rather low. In an extreme case a very high gain array such as an XG21, together with a masthead amplifier, will be required. More commonly however a good 18-element array with a masthead amplifier will provide the most cost-effective solution.

The range of signal levels entering the amplifier is likely to be great. There may be 20dB or more between the strongest channel during winter and the weakest channel during the summer months. It's possible that the input to a masthead amplifier may be too great at times, the result being cross-modulation. It's simple to find the maximum permissible input signal level for an amplifier from the manufacturer's figures for maximum output and gain. The quoted figure for gain is usually accurate, but the maximum output figure, usually quoted for a cross-modulation ration of -46dB across four channels, is often rather optimistic for reliable operation. A good rule of thumb to find the maximum input is to assume a maximum output of +20dB/mV and subtract the gain. If there's any likelihood that this figure will be exceeded, use an amplifier with less gain.

Subjectively, cross-modulation is more annoying, dB for dB, than noise. It's thus more likely to result in a call-back. If this happens, remember that cross-modulation can occur in the masthead amplifier, a distribution amplifier, a VCR or the tv set. Often the masthead amplifier can handle the signal but these latter items can't. If the fault lies with the VCR or tv set, educate the customer in the seasonal use of an attenuator in order to avoid twice yearly call-outs. One of our customers calls her 12dB attenuator her 'calmer downer'.

If you have to feed a large communal system from a tree-screened aerial, channelised units with a.g.c. are essential prior to the power amplifiers.

This type of tree screening problem is often described by the customer as ghosting. When the direct signal from the transmitter suffers maximum path loss, the ratio between it and a reflected signal is at its least favourable. Normal anti-ghosting techniques can be employed, but you'll find the reliability less than you'd expect where trees are not involved. Co-channel interference may arise in the same way.

Fairly close trees in signal path

We'll deal next with fairly close trees that completely obscure the signal path. In a typical case there might be upwards of a dozen large, mature deciduous trees forming an irregular group right across the general direction of the transmitter with the closer trees 20-30m away. The transmitter is a high-power one not too far away and otherwise in line-of-sight. In summer there's little or no clear view through the trees, and even in winter the bare branches significantly obscure the line-of-sight to the transmitter.

The onset of bad reception is as likely in late autumn as in spring. Typically the customer will ring up just after an autumn gale to say that the wind has moved his aerial. He wants you to move it back. It's a simple job and he'd do it himself if he had a ladder/time/or if it wasn't for his bad leg. In fact the wind has removed a lot of the leaves and possibly a few big branches overnight and this has affected reception. How? Read on. The customer is of course expecting an extremely modest bill for a very simple job.

The customer will say that he's enjoyed perfect reception—or what he regards as perfect reception—since the days of John L. Baird. 'Those trees have always been there and they've never affected reception before', he'll declare. The dreaded credibility gap looms up in front of you! In reality the customer has probably always had rather unreliable reception, but it's never

been quite this bad. Why does it happen? Why does one channel just disappear?

The cause of the problem is multipath reception through the trees. The signal takes a number of different paths through the leaves and branches. In the simplest case, if signals following two such paths arrive at the aerial more or less in phase no great harm is done. But if they chance to arrive exactly out of phase and of equal strength the result is no signal. It's never quite as clear cut as this of course. The signal may take a multitude of paths, resulting in a complex and unpredictable pattern of standing waves, or peaks and nulls, at the receiving site. Because a relatively minor change in the tree structure can completely alter this pattern, reception can be acceptable for years until a null happens to occur precisely at the aerial location. Normal movement of the trees, even on fairly still days, is enough to cause great variations in received signal strength.

The difference in path lengths is often not enough to produce visible ghosting, but teletext can be severely affected. Thus the call often originates as 'bad text; picture ok'. Close examination will show that the picture is in fact not ok, but the customer hasn't noticed this.

This phenomenon is very frequency dependent. In comparison with the calculated line-of-sight signal strength, different channels may be received simultaneously at –3 to –4dB. This means that one or more channels might to all intents not be present, leaving the others unaffected. The sound signal on one or more channels might be attenuated to a greater or lesser extent than the vision. Occasionally the sound will be so severely attenuated that caption buzz, hissing or distortion will be present. Tv sound is normally received at –10dB relative to the vision signal. Tv sets and VCRs vary enormously in their tolerance of abnormal sound level signals, but if the sound drops to 30dB below the vision the receiver is in trouble. It's astonishing that Mother Nature can accidentally contrive to produce what is in effect a rather good notch filter.

In the face of such large signal level variations from channel to channel and from one time to another masthead amplifiers are of very limited use. One of the cowboys in our area customarily fits a cheap, unstable, wideband ultra high-gain masthead amplifier in such cases, without making any attempt to improve the signal from the aerial. The usual result is cross-modulation all over the noisy, weak channel. I don't know why people pay him.

Amplification can play a part, but the first essential is to find the optimum position for the aerial. Siting is usually very critical, sometimes astonishingly so. If the aerial is moved up or down or sideways by 300mm while keeping it pointed in the direction of maximum signal pick-up the signal level may vary by up to 20dB. Sometimes the signal at every point on the roof is unusable, but it's far more common eventually to find some small point where all four vision and sound signals are present at reasonable strength. With luck it will be feasible to install the aerial at this point.

These tests are not unlike water divining and need care, patience and experience, not to mention muttered incantations. Start with a prayer, then begin the search at the most convenient location for a permanent installation, working your way outwards. This normally means starting at the chimney and testing very thoroughly all over at all heights. There's a good chance that you will find a conveniently situated point in space that provides an acceptable signal on all channels. This point might be as little as 300mm from the original aerial position. Don't be afraid to fix the array in a position that looks somewhat unorthodox.

Jobs of this kind don't arise because the reception is representative of conditions generally in the district or even on the particular roof. They arise because, by dreadful mischance, the customer's aerial happens to occupy one of the relatively few small points in space where two or more multipath signals cancel out neatly. That explains the 'why me?' syndrome that customers develop when neighbours say, 'we never have any trouble'.

If the trees are really large, with the bulk of the foliage high up, the intensity of the peaks and nulls might be less with the aerial at a lower height. There might be a general improvement in signal levels below roof level. Thus the installer might put the aerial under the eaves or on an outbuilding. Where conventional multipath reflection from the rear is a contributory problem, the house can often be used as a screen.

Polarisation twisting may occur, but unfortunately usually not to an equal extent on each channel. Sometimes what appears to be a normal null is actually a region of near 90° polarisation twisting. If this is a factor the installer should try altering the polarity of the aerial at each possible location. Where polarisation twisting occurs it will not be consistent as the seasons change, so it might be necessary to install two cross-polarised arrays with separate downleads.

There can be such large differences in signal strength over small distances that direct signal pick-up on test equipment is a problem. If an unscreened portable tv set is taken onto the roof the results obtained may be confusing. If the set is in a position where the field strengths are 20dB higher than at the aerial a metre away, connecting the aerial will have little effect on the picture. Any tests made with unscreened equipment are meaningless. Although from an examination of the customer's tv picture it might seem that the problem requires the use of a tv set on the roof rather than simple monitoring of the field strength, in fact it's better to use a meter. Simply look for maximum field strength when all other problems, such as ghosting, should take care of themselves. As a measure of progress, compare the received signal strength with the calculated line-of-sight figure. If you can get within 10dB you're doing well. It's important not to settle for merely adequate signal strength if a better signal is available nearby.

In this concluding instalment I'll give some practical examples to illustrate some of the techniques previously outlined and to show some of the peculiar things the aerial man sometimes has to do when faced with his arch-enemy the tree.

The solitary oak

It was a lovely summer's afternoon. The call was in a small village I'd never visited before. While driving into the village I noted that the Emley Moor transmitter's massive concrete tower could be clearly seen, about five miles away. No reception problems here, I thought cheerfully. The picturesque cottage contained a quaint old lady and a far from quaint up-market tv set. It said 'bad text' on the job card, and this was certainly true. The ordinary pictures were terrible as well, especially ITV. There was no snow but a lot of ghosting and there were rapid signal-level fluctuations. Colour came and went. A meter reading at the bottom of the downledd swung about wildly—by about 20dB. From the front of the row of cottages it seemed inexplicable: the chimney-mounted aerial looked alright.

From the roof the problem was obvious. A solitary oak stood impassively in the middle of the immense lawn of a mansion whose grounds occupied the land behind the cottages. That old lady's roof was the only one in the village from which Emley Moor couldn't be seen, and there was nowhere on the cottage that wasn't behind the spectacular old tree.

I had the usual unsatisfactory exchange with the old lady about why it hadn't happened before—she was convinced that the new tv set was faulty—then suggested that we approach either neighbour to seek permission for the aerial to be mounted on an adjacent roof. Unfortunately she wasn't on speaking terms with either of them—apparently some unpleasantness about a delinquent cat about twenty years ago was to blame—so that was out. Inadvertently, the mansion owner's gardener saved the situation. To make room for his sit-on lawnmower the tree's lower branches had been removed to a height of about two metres. This gave a clear view of the transmitter from under the mass of foliage—provided you were round the back of the cottage on your hands and knees!

After some experimentation an aerial was fixed to the back wall. Its height was quite critical—it

had to be between half and one metre above the concrete path. Fortunately the path was a dead end, and eventually a couple of posts and a rail were installed to fence off the aerial. This installation proved to be completely reliable. The signal strength provided was a constant 23dB/mV. Not quite the theoretical line-of-sight figure, but enough to call for the use of an attenuator.

Problems with a communal system

One of my jobs is to service the communal aerial systems used at a large estate of flats arranged in blocks of twenty four. Most of the blocks have clear line-of-sight to the transmitter. The three that haven't are, paradoxically, on higher ground than the rest of the estate. They are on the lower slopes of a hill that's topped by a dense plantation of mixed trees. These trees form the boundary of a large estate and go back quite a long way.

One summer quite a few years ago the tenants of the middle block started to complain. It transpired that they had suffered from slightly impaired reception during the two previous summers. Now it was really bad. I seem to recall that BBC2 dropped out most severely. Up on the roof it was clear that the trees had grown sufficiently in recent years to obscure the transmitter. When the flats had been built in the mid-Sixties the trees had been nowhere near tall enough to cause problems. As is often the case with a plantation, the tops of the trees presented a fairly regular horizontal line that had moved upwards inexorably as the years passed.

Feeding any sort of communal system from a tree-screened aerial is really bad news. The amplifiers get indigestion, the tenants get high blood pressure and the aerial contractor gets aching legs. It's imperative to find an unscreened location or an alternate transmitter.

The aerial was in the middle of the roof. While walking along the ridge tiles with a test aerial and meter I found a spot where there was still line-of-sight: a narrow fire-break in the trees produced a V in the otherwise straight horizon, and at just one spot on the roof this lined up with the transmitter. There were no funnies. The meter showed correct line-of-sight signal levels on all channels, and within the clear area there were no signal variations. Luckily there was a convenient gable, so an aerial was fixed there pronto. Fifty metres of best-quality Joe Loss—sorry, low-loss—cable took the signal back to the amplifier and the result was magic.

After three more summers the magic wore off. Because of the usual incompetent Housing Association bureaucracy the tenants had been left with really bad reception all summer. This was the year when Channel 4 test transmissions started, and for some reason the new signal was present at the amplifier with sufficient strength to cause cross-modulation. At first I thought that this was the full extent of the problem and wondered why I'd left the amplifier within a few dBs of cross-modulation three years previously.

The tenants were having a right old moan and I was glad to get up the ladder away from all the indignation. On the roof I could see no sign of the V that had been my salvation previously. The fire break had not been maintained—I couldn't even see where it had been. The trees were now much higher. I wondered whether they were bamboo. There was nowhere on that roof with line-of-sight. So I experimented with alternative transmitters. The only possibility gave less than brilliant signal levels however and carried the wrong ITV region—a serious disadvantage with a communal system. It was just possible to obtain line-of-sight with the aerial on a tall mast, but there was nowhere suitable for such an installation and in any case I was reluctant to present the Housing Association with a large bill when the problem would return after a few more years.

The next block along was behind the trees, but because of the lie of the land the transmitter was visible well above them. It wasn't such an expensive job to fit an aerial on that block and get the signal back to the problem block via 150m of CT125. A catenary wire carried the cable between the buildings and a repeater amplifier was used.

Guess what happened next! Yes, that's right. Two years later the tenants of both blocks were up in arms. This time the trees were so high that the living rooms on the ground floor were dark even in sunny weather and what's more the tv pictures had gone funny again. Wearily climbing onto the roof I found that I couldn't even see the transmitter.

For a while it seemed that the owners of the trees could be persuaded to reduce the height of that part of the plantation because of the daylight problem, but it came to nothing. Right I thought, that's it! I'll cure it once and for all! Four blocks away the transmitter could be seen clearly right down to the bottom of the mast. There were no trees below the line-of-sight, just ploughed fields. The building was on low ground and the forest loomed above, well to

one side. I felt that it was an evil but impotent presence.

By now the Housing Association was well aware of the problem. It was unhappy, but was prepared to pay. Trunk cables were installed, linking all the nearby blocks. We were carrying out a schedule of system renovations during this period and ended up with seven blocks fed from one aerial and head-end. The system was well-designed and carefully installed. It should have gone on for ever.

It worked perfectly for years. Until last summer, in fact, when ITV became rather snowy. A refracted signal from a clump of trees near the main plantation was to blame for this. It was reducing the ITV signal levels by 15dB. Not enough to make the picture snowy when fed straight into a tv set as there was still 8dB/mV, but unacceptable for a largish system. A signal going through the head-end and repeaters at 15dB below its fellows gets noisy. There was a bit of ghosting as well.

There was nowhere on any of those large roofs, and I tried them all, where correct signal levels could be obtained. This effect is very variable with time of course, so channel equalisers were not the answer. I could get things fairly well done at certain locations, but there was nowhere that I felt confident about. I suppose I could have fitted channelised preamplifiers with a.g.c. and hoped for the best. In the event I moved the aerial to a location where all the channels were within 7dB of each other and added signals from the remote transmitter with the wrong ITV programmes. The tenants were all given a leaflet to show to their tv engineers. It explained the problem and suggested that all eight signals should be tuned in. Signal levels from the local transmitter were set at the amplifier as if they were normal line-of-sight. They could on occasions go a bit snowy if they wanted to, but they couldn't cause cross-modulation. This ploy seems to have worked well so far.

Aerials on trees

It's not that unusual to have to fit an aerial on a tree—this is about the only occasion when a tree will help the aerial man. A tree-top installation is often the only practical way of obtaining line of sight over an obstruction. Needless to say the obstruction is usually the other trees.

In this particular case the customer lived in a bungalow with dense, close woodland that prevented reliable reception from the only possible transmitter. Over the years I'd moved the aerial from one place to another on the roof, always with an unsatisfactory and short-lived improvement. The only garden sloped downwards from the bungalow on the side away from the transmitter, so the roof was the obvious place for the aerial—except that there was one really tall tree at the bottom of the garden. Although the tree's base was on very low ground, observation from a distance showed that its top was definitely line-of-sight. Over the years I kept trying to persuade the customer to let me put an aerial on top of the tree, but he was worried about what he called the aesthetic aspect. I would ask him which he looked at most, the top of the tree or the tv picture. Finally his wife made him see sense. I don't like climbing trees, but a man's gotta do what a man's gotta do.

It was a pig of a job. It was raining on the day and the only access to the tree was down the steep, muddy lawn. I'll draw a veil over the hazards of working with a chain saw at the top of such a large tree. A few branches were removed so that the tree didn't obscure the aerial. The downlead was routed from the base of the tree along a fence to the garage, then overhead to the bungalow. I fitted an amplifier about half way along the cable run and a distribution amplifier in the loft to feed five outlets. There have been no further reception problems.

As long as care is taken to remove obstructing branches, the movement of a tree in the wind has surprisingly little effect on reception from an aerial it supports.

The upside down aerial

A local relay is not the complete answer to poor reception in a particular neighbourhood. In this case the prominent feature of the town was its castle. It stands on a rocky outcrop whose lower slopes are wooded. The appropriately named Low Road skirts the castle grounds. There are hills surrounding the area, except in the direction of a high-powered transmitter 30km away.

Reception directly behind the castle is awful. A low-powered relay transmitter was finally provided but was a great disappointment. It only serves about a quarter of the houses that need it, transmitting a highly-directional beam to one small area. When the BBC and IBA plan these things they drive around the area in a Range Rover with a log-periodic aerial on a telescopic mast. An afternoon of this is the full extent of

their research. They haven't a hope of discovering all the nooks and crannies where reception is bad. If they asked all the local riggers to mark the bad reception on a large-scale map they would learn far more at less cost. The excuse given for installing these highly-directional, under-powered relays is that anything better might cause co-channel interference outside the area. But in a lot of cases, including this one, the excuse is invalid since the transmitter is screened all round by high ground.

One particular customer had terrible reception through the trees that surround the castle. He'd tolerated it for years on the promise of this eagerly-awaited relay. When it came into operation I was unable to get more than –12dB/mV from it at the site, and that was with severe ghosting. The transmitter was only about 700m away, but the transmitting aerial pointed in the wrong direction. Reception of a sort was possible by directing the aerial at the castle and receiving the reflection, but this signal wasn't good enough to use.

Having established that the new relay was a washout I started looking towards the main transmitter. The trees are very close and very dense. After some time I found one point on the roof where the signal levels reached the dizzy heights of 0dB/mV. This is 20dB below the line-of-sight figure so it wasn't good, but it was much better than the levels of the signals coming from the existing aerial—one channel was at –27dB/mV. The relevant point in space was at the base of the chimney. High ridge tiles made it impossible to fit a lashing wire low down, while the brickwork was in such poor condition that a wall bracket would have been unsafe. I installed a chimney lashing kit with the mast protruding downwards, then fitted the aerial at the bottom of the mast, just above the roof level. Because a long downlead had to be used a low-gain masthead amplifier was fitted—with some misgivings about the possibility of cross-modulation in winter. This greatly improved the reception. I warned the customer that this improvement might be short-lived, but in fact the installation has proved to be fairly reliable and no further work has been required.

Customer relations

If there's no alternative to obtaining reception through dense foliage the aerial install must make plain to the customer the limitations of what can be achieved. There is no guarantee of reliable reception under these circumstances: if you offer a guarantee, even if only by implication or by the omission of a disclaimer, you are making a rod for your own back. You must honour the normal warranty on materials and workmanship of course—this is a legal requirement and a good tradesman will do this automatically. But you can't be held responsible for any tricks that trees might pull. In other words you are responsible for the aerial but not for any variation of the incoming signals at a later date.

It's all too easy to be held responsible for things that are beyond your control. The result can be a lot of hassle. Explain the problem to your customer fully. People often assume that they should be able to get perfect reception no matter where they choose to live. You must dispel this illusion. Give the customer an honest assessment of the chances of achieving reliable reception and explain the ground rules before you install the aerial. If you see a wildly expensive solution that would be absolutely cast iron, such as a remote aerial and a 500m downlead, let the customer know about it. If he rejects the idea in favour of a cheaper solution you've transferred a large part of the responsibility to him.

If you find yourself with a customer who cannot accept this limitation of your responsibility and insists on an unconditional guarantee you must decline the job. Cut your losses and leave him to the mercy of the local cowboys. As you drive past the house over the next few years you'll have the amusement and satisfaction of seeing a quick succession of jerry-rigged aerials appear on the roof, probably ending up with a hopeless wideband DIY special. Remember that if a person lives in a place where tv reception is unpredictable it is, initially, his problem. It becomes yours only with your prior agreement, which must be on your terms.