wideband BAND I aerials

Roger BUNNEY

The wideband aerial has made itself known in recent years for use on Band III and at u.h.f. There has, however, been little or no demand for an array with total Band I coverage in the UK mainly because a common BBC-1 programme is transmitted on all Band I channels with only the occasional regional variation. In the Americas and other parts of the world alternative programmes are available on the channels in Band I (Low Band to use the American term) so that aerials for this use with a wide or semi-wide bandwidth are commonly available.

For long-distance television reception (TV-DX) and for use in certain areas overseas where alternative programmes are available from neighbouring countries, a wideband Band I array is extremely helpful, especially if used with an aerial rotor unit. It overcomes the need to erect separate arrays for each Band I transmitter and the inconvenience of replugging aerial feeders: instead a single high-gain array with maximum performance on all the required channels is employed.

Wideband Band I arrays have been in very limited use in the UK for a number of years, mainly for TV-DX use. Unfortunately however commercial wideband Band I arrays are not readily available as there is so little demand. There also appears to be a lack of any information on aerial design for wideband Band I coverage. To this end this article presents three such designs together with basic information on how they were evolved.

Basic Aerial Characteristics

A half-wave dipole cut to a particular frequency will absorb maximum signal energy from an electromagnetic field oscillating at that frequency. The bandwidth of a single half-wave dipole depends to some extent on the diameter of the rods used for the dipole elements and the frequency. It is common practice to use ½in. elements for Band I and ¼in. thickness elements for Band III. These diameters allow sufficient bandwidth to cover a single channel efficiently.

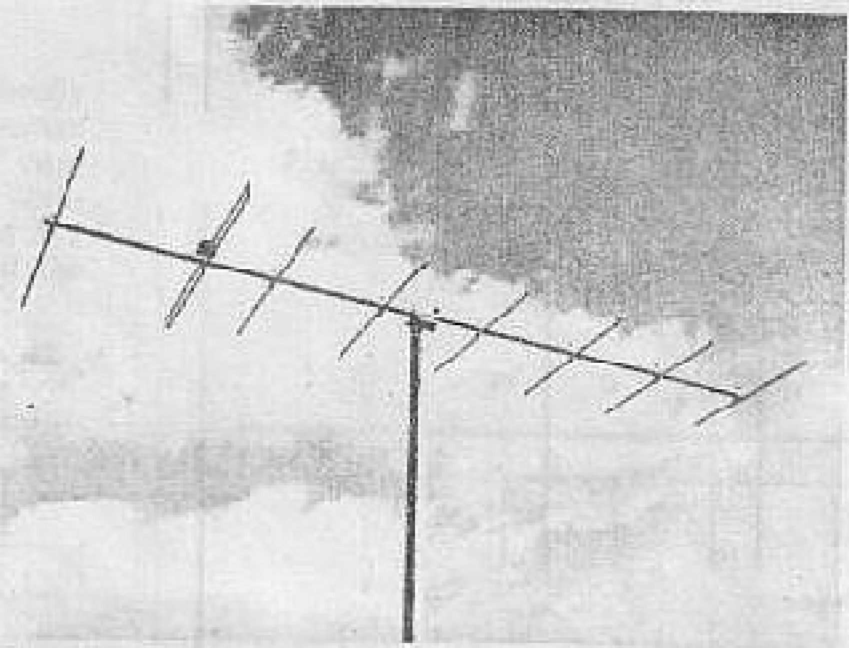
The impedance at the centre of a half-wave dipole is 75Ω and to achieve maximum transference of signal energy to the receiver, cable having a characteristic impedance of 75Ω must be used. Coaxial cable having a characteristic impedance of 75Ω is normally used in the UK but alternative feeders and impedances may be encountered in other parts of the world. Ribbon feeder with an impedance of 300Ω is, for example, commonly used in Europe and the Americas. If the aerial does not match the feeder accurately there will be signal loss, the amount depending upon the extent of the mismatch. Similarly if the cable is terminated with a device such as a receiver or aerial amplifier that does not present an accurate match to the cable impedance further losses will result. Reflections will occur due to the mismatch and an effect known as standing waves will be set up. This effect is measured as the ratio of the maximum to the minimum current or voltage along the line and is termed the standing wave ratio (S.W.R.). A further point to bear in mind is that the thickness of the dipole elements affects both the bandwidth of the system and the dipole impedance.

Yagi Array

To increase the gain of an aerial system additional elements can be added adjacent to the dipole. Such elements mounted in front of the dipole are known as directors and are slightly shorter; elements mounted behind the dipole are known as reflectors and are slightly longer than the dipole. Unfortunately increasing the gain of an aerial system by adding such elements (known as parasitic elements) lowers the dipole impedance. The extent of the variation of the dipole impedance and the gain of the array depend upon the spacings of the parasitic elements relative to the dipole. Consequently to use such an array some method is necessary to return the dipole impedance to 75Ω so that there is a correct match to the feeder.

Matching and Bandwidth

The single dipole can be folded, giving a four times increase in impedance. Alternatively the dipole can be tapped at a point where the impedance is 75Ω; this method is known as delta matching. The bandwidth of a folded dipole array will tend to widen somewhat, whereas the delta matched array will remain relatively unaffected. A close study of the many current commercial u.h.f. arrays shows that various methods are adopted to give an accurate match over the bandwidth of an aerial group. J Beam make use of a special transformer—their patented inverse balun. Aerialite and Antiference use specially shaped dipole



The Astrabeam wideband Band III array type ABM8 (J Beam Engineering Ltd.).

units with variations in the element thickness. The purpose of this is to reduce the capacitive and inductive reactance swing either side of the dipole resonance point in an effort to maintain a central 75Ω dipole impedance to match into the feeder. On such arrays the director and reflector elements are cut to dimensions somewhat greater than the usual 5% limits used on many single-channel aerials. This is done to obtain the required wide bandwidth operation. The J Beam Astrabeam Band III array (see photograph) which has a 170-220MHz bandwidth is an example of this method of tuning the active and parasitic elements to various frequencies within the desired bandwidth: the reflector is tuned to the low-frequency end, the dipole to mid-band and the director(s) to the high-frequency end of the band. The J Beam inverse balun ensures that an accurate impedance match is obtained over the band.

Arrays for Band I

We can in a similar manner construct an array for Band I with a coverage over the band and reasonable performance. It is impossible without the use of expensive measuring equipment to produce an array which gives an accurate match over the band but the designs shown (Figs. 2-4) will enable the constructor to produce an array with a reasonable performance sufficient for all but the most demanding requirements.

The problem of matching accurately into 75Ω over a bandwidth of 30MHz at Band I is considerable. Consequently two of the designs use a conventional straight (unfolded) dipole whilst the third one goes some way to achieve an improved match over the 30MHz bandwidth by using a parasitic dipole. Despite the apparent disregard for matching on two of the designs the performance is adequate over the bandwidth and good results have been obtained over a number of years by long-distance television enthusiasts.

All three designs use elements tuned to various parts of the desired bandwidth. In each case the reflector is tuned to the low-frequency end of the band at 40MHz, the dipole is cut to mid-band at about 55MHz and the director(s) to the high-frequency end at 70MHz. Additional reflectors may be added to improve the front-back ratio.

Practical Designs

The designs shown in Figs. 2 and 3 are basically similar. J Beam's three-element design has coverage over 40-70MHz, with the 75Ω coaxial feeder connected directly to the straight dipole. J Beam comment that with such an array a voltage S.W.R. of 3:1 can be expected over the total bandwidth and the

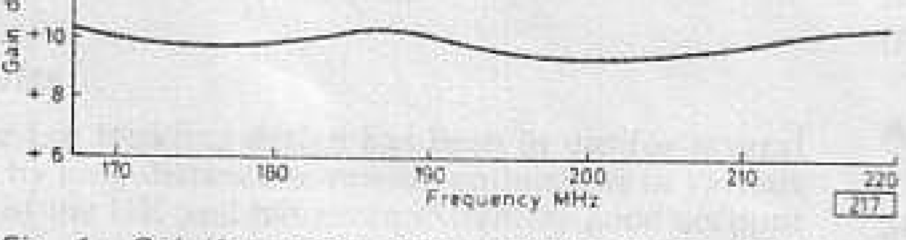


Fig. 1: Gain/frequency characteristics of the Astrabeam Model ABM8, showing the level response over the bandwidth.

Antenna Engineering Handbook by Jasik states that a practice has been established for a 3:1 V.S.W.R. with a two-band array and 2:1 for a single-band array.

The array designed by Ian Hickling (Fig. 3) is similar but has rising gain at the h.f. end of the band. It gives a gain of 6·5dB at 40MHz rising to 8·5dB at 70MHz. Reference to the *Antenna Engineering*

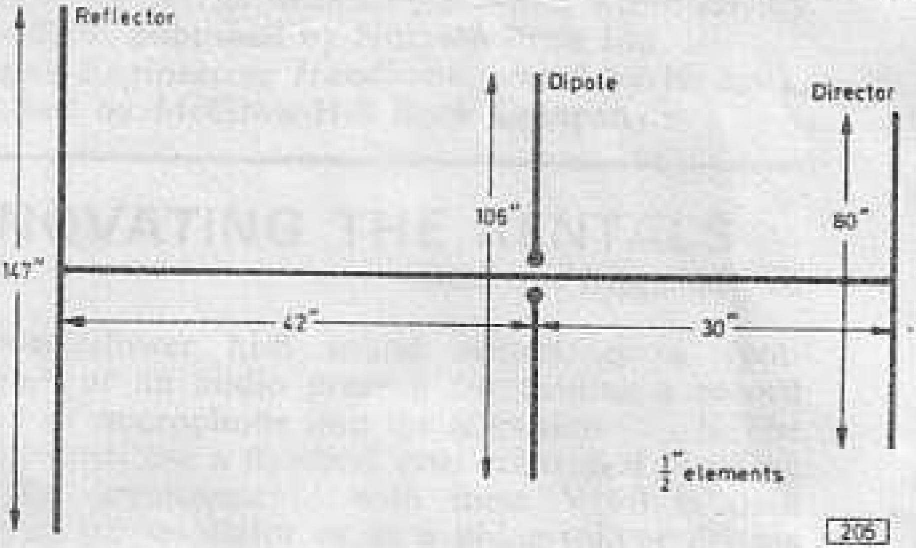


Fig. 2 : Three-element design by J Beam.

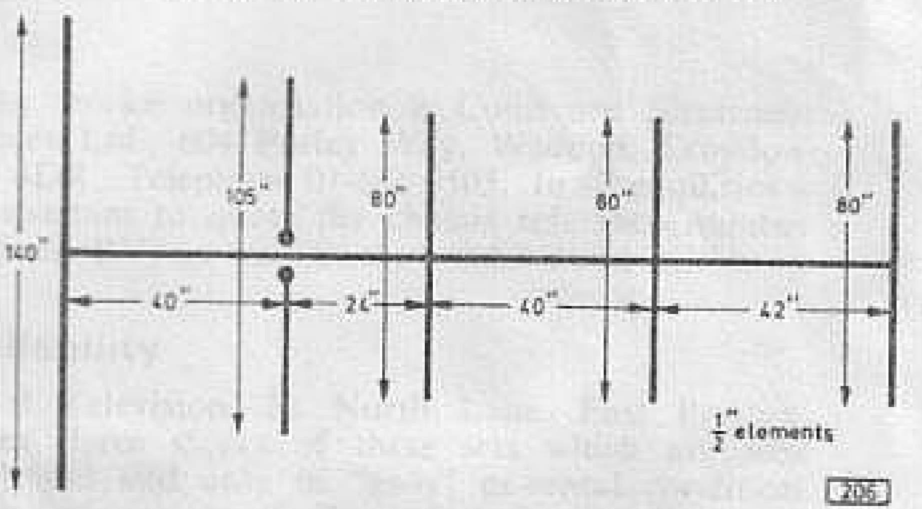


Fig. 3 : Five-element design by Ian Hickling.

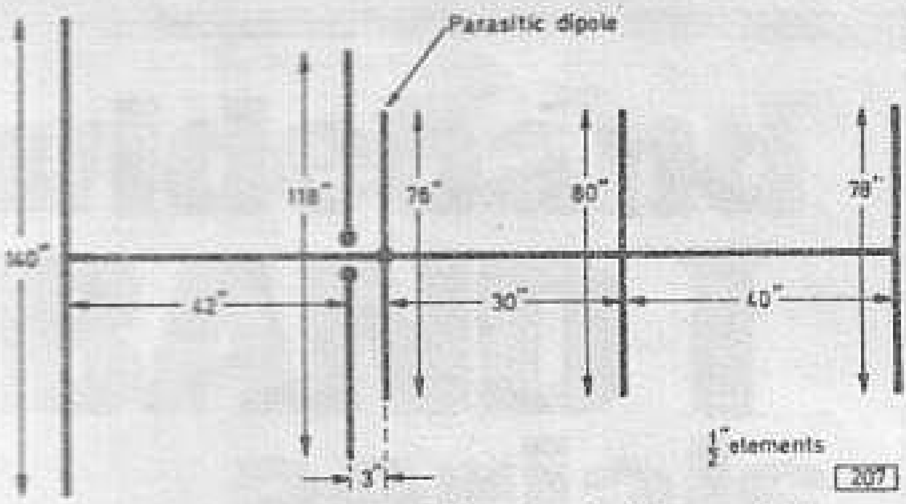


Fig. 4: This four-element design by Antiference Ltd. uses their Tru-Match dipole system.

Handbook indicates that with arrays of this type (i.e. having several directors) there is a tendency for a slight fall in gain over the central part of the frequency bandwidth. For our purposes however this effect can be ignored. Ian Hickling comments that the advantages of a single-radiator system (it is often more convenient to consider a receiving dipole in its reciprocal role as a transmitting element) are that the reflector and directors steer the radiation from the point source in a more predictable manner than would happen if multiple radiators were used to obtain a wide bandwidth coverage. This results in a cleaner polar diagram.

The third design (Fig. 4) shows a suggested wide-band array by Antiference Ltd. with a measure of impedance correction over the extended bandwidth. Antiference comment that: "The length of the driven dipole is longer than half wave so as to be inductive at the lowest frequency while the parasitic dipole is less than half wave so as to be capacitive at the highest frequency. This produces at resonance a resistive impedance higher than that obtained with a single straight dipole (which would be much lower than 75Ω in the two examples shown in Figs. 2 and 3) while at frequencies off resonance the reactive swings are much lower due to the mutual correction provided by each dipole element. The ratio of driven to parasitic element length increases as (i) the transformation impedance ratio required increases and (ii) as the required bandwidth of the array increases." Antiference also suggest that a certain amount of experimentation around the dimensions given may help, particularly the dipole lengths.

Reflector

Each design uses a reflector tuned to 40MHz. The bandwidth could however be decreased somewhat, say to 45MHz. The formula 468/*f*(MHz) gives the resonant length in feet. A double or even triple reflector configuration as shown in Fig. 5 could be used. This will have little effect on gain but will improve the front-back ratio somewhat.

Results

The Ian Hickling design has been in use for several years by long-distance television enthusiasts in various parts of the UK and has given extremely good account of itself. At my previous location in the Romsey, Hampshire area I was able to receive the 10W Ventnor relay at some 30 miles on a daily basis despite a very shielded location and a hilly transmission path. In

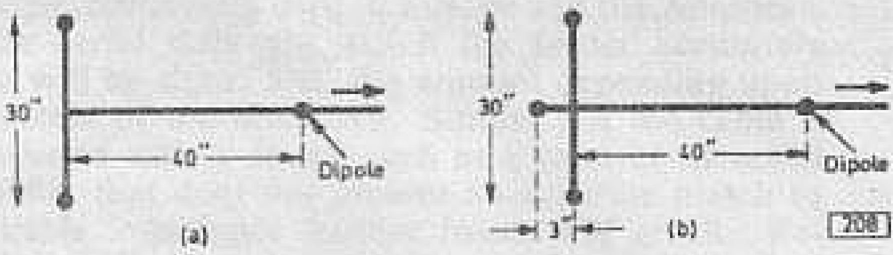


Fig. 5: (a) Double reflector; (b) triple reflector.

passing it is worth pointing out that although an array of five elements possesses fairly good directivity which is ideal for weak Tropospheric signals it can be a disadvantage with Sporadic E signals: I have on more than one occasion missed signals from Finland on ch.E2 with my array aimed to the south-east whilst a near colleague tuned to the same channel was receiving weak signals from the Finnish transmitter using an omni-directional Band I array. Thus it may be better to use a three-element design to exploit its wider forward acceptance angle despite its lower gain. It is of course essential to use three elements in order to obtain the required resonant points and hence the bandwidth.

Finally we are looking into the possibility of a companion wideband aerial amplifier using field effect transistors for use with these wideband Band I arrays.

Acknowledgements

Our grateful thanks for information and assistance to: V. R. Hartopp, J Beam Engineering Ltd., Northampton; F. J. Tomlin, Antiference Ltd., Aylesbury, Bucks; and I. Hickling, Moulton, Northants.

References

Practical TV Aerial Manual for Bands I and III, by R. Laidlaw, published by Norman Price Ltd.

Antenna Engineering Handbook, edited by H. Jasik, published by McGraw-Hill Book Company.