Antenna Workshop

David Butler G4ASR describes how to build a seven-element Yagi antenna for use on the 70MHz Band.

The 70MHz 7-element Yagi antenna that's featured this time, above a 50MHz 6-element Yagi.

As a keen v.h.f. operator I've always taken a special interest in the DX capabilities of the 70MHz band and if you take a look at my VHF DXER column this month you'll see what I mean. To achieve consistent results, I wanted an excellent antenna with a very clean pattern, a good amount of forward gain and something that's easily reproduced.

The antenna I've chosen, comprises of seven elements mounted on a boom that's a little over 6.5m long. So, if you're planning to build a 70MHz moonbounce array, this is the antenna for you! I realise that the antenna shown in the photograph is great but that not everyone has the space for such a monster! However, the techniques and constructional methods are transferable!

Design

The seven elements are: a reflector, driven element and five directors as shown in the diagram, **Fig. 1**. Note: part of this design is that some of the directors don't get progressively shorter as with other Yagi models. All parasitic elements are positively fixed to the surface of the boom via metal fixing plates and stainless steel fixings so, possessing a slight advantage in terms of noise and discharge of static build-up.

The driven element assembly, comprises of a split feed with a hairpin match. This is superior to gamma matching as it eliminates tedious adjustments and is far more reliable. The antenna terminates in a 50Ω female N-connector fed via a coaxial choke balun. The design has been modelled in *EZNEC* and the predictions confirmed with practical examples. At 70.200MHz, it possesses a peak gain of 10.8dBd, a 3dB beamwidth of 42° and a 30dB front-back ratio. The v.s.w.r. is essentially flat (<1.1:1) across the band although it has been designed for use at the lower end of the 70MHz allocation.

If the antenna is to last a long time, the grade of aluminium used is paramount. The boom on my antenna was made from aerospace quality HE30 grade alloy, as this has excellent corrosion resistance. All the elements were made from 12mm aircraft grade 6061-T6 aluminium tubing and are attached to the boom clamps by sliding into a length of 15mm diameter 0.028in wall thickness 6061-T6 tubing. This creates a double wall at the centre of the elements without excessive clearance between the inner and outer tubes. Some designs use thinner tubing that's cheaper and easier to obtain but isn't a good fit within the tube used for the element outer sections.

The 6061-T6 grade aluminium has excellent characteristics for antenna construction though it's not readily available in the UK. The boom-to-element clamps are made from thick alloy plates securely fixed to the boom to ensure that the elements cannot become misaligned in high winds. Finally, M4 stainless steel bolts, nuts and shake-proof washers are used for all fixings to give a trouble-free performance.

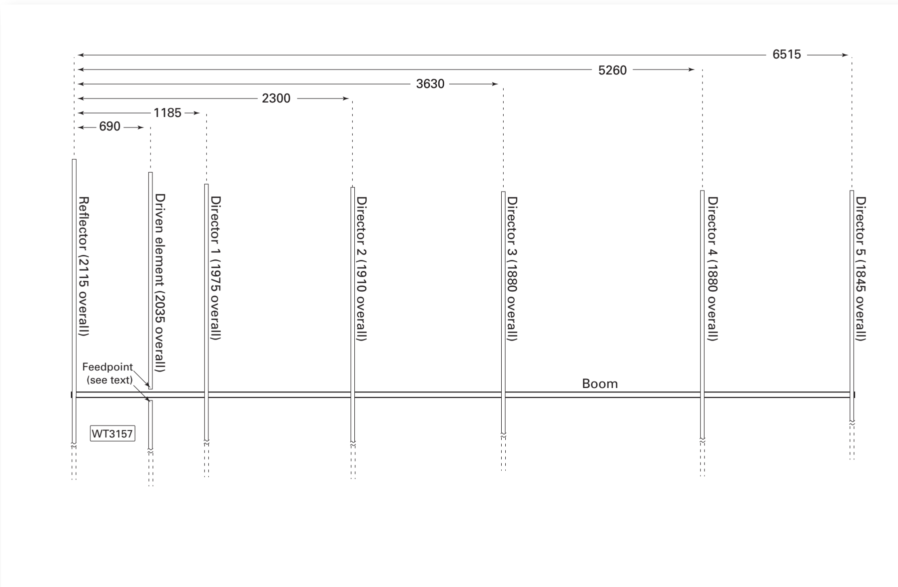

Fig. 1: A diagram of the antenna that doesn't follow the 'normal' Yagi Layout.

Construction

Start the construction of the boom by cutting the 31mm (1.25in) aluminium square box section into four equal 1650mm lengths. To join the boom sections together cut the 28mm (1.125in) aluminium tubing into three equal 300mm lengths. These are slid into three of the boom sections as shown in the photograph, **Fig. 2**, and riveted into place.

Then mark out the 75mm (3in) square alloy plates and drill four M4 holes as shown in the photograph **Fig. 3**. These plates are used to mount the elements on to the boom.

The materials I used are shown in **Table 1**. You could opt to use cheaper and more readily available materials as long as the dimensions are adhered to.

Now you need to measure, mark out and drill holes in the boom to suit the element retainers that are to be attached as shown in Table 1. Note that you must align the centre line of the plate exactly where the element should be placed. Measure all spacing dimensions from the reflector position rather than marking out between each element. By referencing all dimensions to one starting position you reduce inaccuracies that might accumulate along the length of the boom.

Cut eight 150mm lengths of 15mm (0.625in) diameter tubing and attach six of them centrally to the element retainers as shown in Fig. 3. The driven element is constructed differently as shown in the photograph **Fig. 4**. The dipole elements are insulated from the retainer plate by the use of plastic central heating fixings. A 50mm length of fibre-glass insulating rod is placed between the centres of the split dipole to create a 12mm gap.

Now, the elements are cut to length and attached to the main boom with the associated clamps. The dipole elements are made in a similar manner but consist of two separate pieces. As a purist I used conductive grease on all aluminium-to-aluminium joints.

This Yagi uses a hairpin match (sometimes known as a Beta match) to raise the 28Ω feed-point impedance to 50Ω. It's made from a 440mm length of 5mm diameter solid aluminium rod. The hairpin is 205mm long by 30mm wide with flattened ends that attach to the driven elements and balun assembly as shown in the photograph **Fig. 5**.

A 125mm long off-cut of the 31mm square boom material is conveniently used to house a 1:1 coaxial choke balun. Conventionally, this is a length of coaxial cable slightly shorter than a $\lambda/4$ wavelength long coiled up as close as possible to the driven element feed-point and then taped to the boom. This 70MHz Yagi uses 800mm of RG58 cable tightly coiled up and slid into the balun housing. One end of the cable is attached to a female N-connector and the other end connected to two short 'pig-tails' terminated in M4 solder tags to connect to the dipole feed-point.

To complete the construction plastic caps are fitted to the ends of the boom and antenna elements. The Yagi is attached at the balance point with a suitable mast clamp but it will require a support to prevent drooping of the main boom. An effective method is to support the boom approximately 175mm from each end with Draylon cord fixed to a small clamp above the main boom.

Results

I constructed two of these antennas that had effectively identical responses (they were eventually stacked 5.6m apart to give approximately 14dBd gain). Neither antenna required any matching adjustment, both possessing a very low standing wave ratio, even during periods of heavy rain. It's difficult to quantify the absolute gain of this antenna but it has subjectively more gain than a 6-element NBS Yagi that I've previously used. The antenna pattern appears to be very clean with a good drop-off in signal strength as the antenna was rotated away from the received station.

If you build this superb 7-element antenna you will discover a great improvement in your 70MHz station capabilities. If you don't have the time to procure all the materials and build one it is possible to buy a similar 7-element Yagi from **Vine Antenna Products (01691 831111).** ●

Table 1:

Materials
7m of 31mm (1 1/4") HE30 grade aluminium square box (boom)
1m of 28mm (1 1/8") 6061-T6 grade aluminium tubing (boom joiners)
14m of 12mm (1/2") diameter 6061-T6 grade aluminium tubing (elements)
1.5m of 15mm (5/8") diameter, 0.028" wall thickness, 6061-T6 grade aluminium tubing (element centres)
450mm of 5mm (3/16") diameter 6061-T6 grade aluminium rod (hairpin match)
7 off 75mm (3") square x 3mm (1/8") thick aluminium alloy plate (element/boom clamp)
Various M4 Stainless Steel fixings and plastic end caps for boom and elements

Fig. 2: The Boom Joiner.

Fig. 3: The Element Plate.

Fig. 4: The Dipole Plate.

Fig. 5: The Hairpin Match & Balun Assembly.