Optimizing the SteppIR 3-Element Yagi for 6m

The SteppIR 3-element Yagi is a very popular antenna for all five bands from 20m to 10m, but we don't hear the same praise for its performance on 6m. Although SteppIR offer an additional 6m director as a 'factory modification', this does not give the performance that an experienced 6m DXer would expect from a *good* 4-element Yagi.

As we well know, almost any antenna will work on 6m when the band is wide open; but the real tests are in competitive situations such as contests and pileups, and marginal situations with weak DX signals. The SteppIR factory modification proved consistently uncompetitive in those situations, which strongly suggests that the antenna was not delivering the claimed forward gain. Other evidence that the antenna was not working well included poor front/back ratio (F/B) and SWR, and extreme sensitivity to rain, dew or frost on the fibreglass tubes – much more so than on the lower bands.

Those problems can be solved by re-optimizing the antenna to use *two* parasitic elements for 6m. As well as the additional director, this new modification has a dedicated 6m reflector 'in the right place'. The two new elements are very easy to build, using off-the-shelf parts and an absolute minimum of tools. Simply build them as specified below, clamp them onto the boom of the SteppIR at the specified locations (no holes required) and the mechanical work is done.

Another important benefit of this new modification is that you can *always* verify that the SteppIR variable elements are correctly tuned – quickly, easily and without leaving the shack. And best of all, you will find that de-tuning by rain has almost completely disappeared.

Instead of a compromise, your SteppIR will now be an optimized long-boom 4-element Yagi for 6m which *always* delivers the performance you can expect from a Yagi of this size.

What's Wrong with the 'Factory Modification'

The option to use the existing three SteppIR elements on 6m is scarcely worth mentioning. All it does is to shorten the three elements, but the resulting antenna performs very poorly indeed because the spacings between the elements are ridiculously wide. SteppIR fully accept this, which is why they offer the 'factory modification', a fixed-tuned 6m director which is inserted into the gap between the driven element and the front director.

But the factory modification doesn't work well either, because the extra director was only 'half the job'. The reflector spacing is still much too large for 6m (Figure 1). Re-tuning the SteppIR reflector is not enough to compensate for that grossly incorrect spacing, so it leaves the Yagi with poor performance in real life.

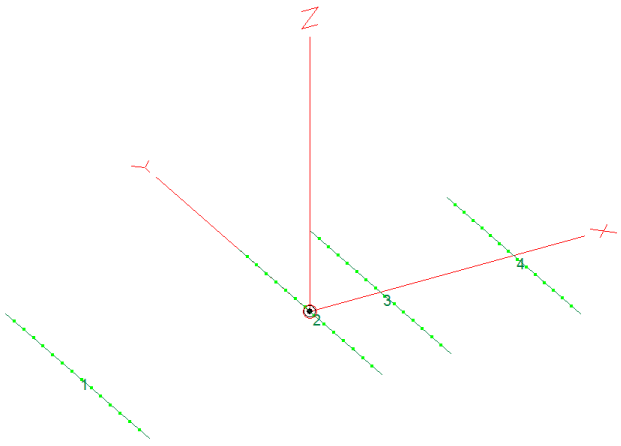

Figure 1: SteppIR's 'factory modification' inserts a new director (Element 3), but the reflector (Element 1) is positioned too far back for optimum performance.

A particular problem about the incorrect reflector spacing is that it makes the entire antenna extremely sensitive to de-tuning by rain, dew or frost on the fibreglass tubes. Both F/B ratio and SWR are affected, so the forward gain is sure to be affected as well. The SteppIR control box has an option to correct for de-tuning by changing all three element lengths by the same percentage amount, which works fine on 20-10m but is not accurate enough for 6m. This leaves the user with the impossible task of re-tuning three individual, interacting element lengths.

The third major problem is the SteppIR documentation. SteppIR have made a number of very worthwhile product improvements over the years – the construction of the fibreglass tubes has changed (very much for the better), the original controller has been replaced by the SDA-100 and there have also been a number of firmware revisions. But the SteppIR documentation has not kept accurate track of all those changes, and owners cannot be confident that the element dimensions for the 6m modification have been specified correctly at all times.

The new modification solves all of those problems.

The Optimized Option

Looking for better performance, I decided to start again – this time using **two** new purpose-made elements for 6m: a new reflector as well as the extra director. The whole antenna design was then re-optimized to make a 'proper' 4-element Yagi for 6m. The SteppIR reflector is fully retracted, leaving only the original SteppIR director and driven element in play. The old SteppIR 6m director is removed because it is not the right length for the new design.

Computer optimization used the *Antenna Optimizer* (*AO*) software by Brian Beezley K6STI and predictions were checked using *NEC2* (*EZNEC+* v5). The scope for optimization was somewhat limited because we cannot change the distance between the front director and the driven element; and we also have to aim for a specific feedpoint impedance of 22Ω because the driven element contains a 50:22Ω impedance transformer. Even so, *AO* has produced a very competent design.

As you can see from Figure 2, this now looks like 'a proper 4-element Yagi' with much more sensible element spacings and a tight rearward pattern. Predicted forward gain is close to 10dBi (in free space) which is about right for a wide spaced 4-el Yagi of that overall electrical boom length (3.7m). The new antenna has a very similar boom length to the well known 5-element Tonna, and the two antennas are closely comparable in gain and pattern which is exactly what you would expect. The forward gain is also very close to the *claimed* gain of the SteppIR factory modification.

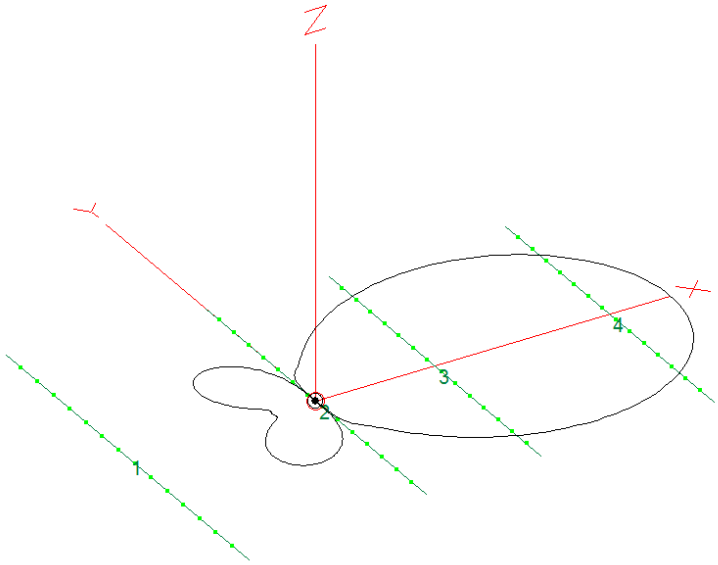

Figure 2: Optimized 4-element Yagi for 6m has the same forward gain but has a better radiation pattern and can be accurately adjusted.

There was a special reason for optimizing the rearward pattern for a deep null at 180°. The only SteppIR variable element that has a significant effect on the F/B ratio is the front director (Element 4 in Figure 2) which makes it very easy to adjust that element to the correct electrical length. Simply adjust the front director for the deepest possible null, directly off the rear. When you have found the null, the rest of the radiation pattern will be correct as well.

The length of the driven element (Element 2 in Figure 2) does not affect the radiation pattern – it only affects the impedance match. So after tuning the SteppIR director for a rearward null, you finish off by adjusting the driven element for minimum SWR. Both of these adjustments can be repeated at any time using the SteppIR controller in the shack. It only takes a minute and the new settings are automatically saved for future use.

But it is very important to understand that this tuning procedure for the SteppIR variable elements depends on the other two elements – the new 6m reflector and director – each having **exactly** the correct electrical length. So...

You MUST construct the new reflector and director EXACTLY as specified below!

Construction

This is important – the tubing diameter, the telescopic centre section and the element mounting method will all affect the electrical length so they **must not be changed** from what is specified below.

Figure 3: Construction of the two new elements.

This is not the place for a tutorial on how the element diameter and mounting method will change the electrical length. If you aren't already aware of this[1] then please, just take it from me:

- Copy **ALL** of these construction details **EXACTLY** (or else it won't work properly)
- **DO NOT** use any other sizes of tubing (or else it won't work properly)
- **DO NOT** use any other type of element mounting (or else...)
- **DO NOT** try to use the existing SteppIR director (it's the wrong length)
- **NO EXCEPTIONS** (ye cannae change the Laws o' Physics).

The new elements are designed around ½-in and ⅝-in tubing diameters because those are still more readily available than metric diameters in the UK. The centre part of each element is a 12-inch length of ⅝-inch OD aluminium tubing as shown in Figure 3. Telescoped inside this is the main element which is made from ½-inch OD tubing, cut to the overall lengths specified below. If your supplier cannot deliver long lengths of tubing, you could use two half-lengths butted together in the middle.

1. The insulated clamp and the ⅝-in sleeve have been carefully chosen, not only to have *small* effects on the electrical length, but also to have *opposite* effects which will tend to cancel each other out.

The telescoping tubes must be fixed together with a good electrical connection at each end of the ⅝-in section, either by stainless steel self-tapping screws or by slitting the ends of the larger tube and using hose clamps. If the elements are made using two pieces of tubing, additional fixing screws will be needed at the centre joint. Waterproof all joints and screw-heads using heat shrink tubing or tape as appropriate.

Each element is fixed to the boom using two plastic Stauff clamps and a standard 'long' U-bolt and saddle, as shown in Figure 3. The M6 U-bolt passes through one of the 6mm fixing holes in the two-part plastic clamp, so the element is positioned slightly off-centre above the metal saddle. The Stauff clamp is held firmly closed by an M6 x 30mm stainless steel cap screw through the other hole. Use Nyloc nuts for a secure fixing.[2]

Everything can be ordered on the web:

- Telescoping ½-in and ⅝-in tubing
- Long U-bolts and saddles
- Stauff clamps (Imperial size ⅝-in OD)
- Stainless steel screws, nuts and washers.

A complete kit is available from Aerial-Parts of Colchester (http://www.aerial-parts.co.uk).

Element Lengths and Locations

Cut the two elements accurately to length, centre each element between its two Stauff clamps and position it accurately on **top** of the SteppIR boom, in the same plane as the existing elements:

- Overall length of new reflector = 125.0 inches (3175mm).
- Position of reflector = 57.5 inches (1460mm) behind centre-line of driven element.
- Overall length of new director = 109.5 inches (2780mm).
- Position of new director = 36.25 inches (920mm) forward from centre-line of driven element.

Double-check all of your measurements, to avoid puzzling problems when trying to tune up!

Tune-up

The procedure varies slightly, depending on which SteppIR controller you have. The following instructions are for the newer SDA-100, but are easily adapted to the older controller.

1. Carry out the SteppIR **CALIBRATE** procedure first, which resets all elements to the correct 'zero' length.
2. Make sure that the frequency on the SteppIR controller is set to **50.1MHz**, either by using the **BAND** buttons or through the data link from your transceiver.
3. Tap the **SETUP** button to enter the SteppIR setup menus. Within these menus, use the **BAND up/down** arrows to scroll through the menu until the item you want is flashing, and then tap the **SELECT** button.
4. Select **Options Menu** followed by **6m**. Make sure that **6m Option** is set to **YES**. If you changed this from NO, make sure that your new **YES** selection is saved (see your controller instructions).
5. To exit from **Options Menu**, scroll around to **DONE** then tap the **SELECT** button.
6. Use the **BAND up/down** arrows to move along to the **Create/Modify** menu, and tap the **SELECT** button to enter.

2 This element mounting method has been tested up to Storm Force 10. Any attempt to 'improve' it by drilling centre holes or using backing plates will change the electrical length and affect the performance.

7. Select each element in turn, and then use the **COARSE** or **FINE up**/**down** arrows to set the new element lengths as follows (lengths in inches).
   - **REF** 4.5 (fully retracted)
   - **DRV** 109 (driven element)
   - **D1** 102
   - **D2** Ignore (does not apply to your 3el SteppIR).

   By now the antenna should be close to resonance and you will probably be hearing some band noise.
8. Tune your transceiver to a reasonably strong 6m beacon, and rotate the beam to exactly the opposite direction. Re-adjust **D1** for the deepest possible null in that reverse direction
9. Move away from the beacon to a frequency where it is OK to transmit, and adjust **DRV** (the driven element) for the best possible SWR, which should be 1.5 or lower.
10. To exit the **Create**/**Modify Menu**, scroll around to **DONE** then tap the **SELECT** button. Your new antenna dimensions should automatically be saved (though it's a good idea to confirm that).
11. Finally, tap **SETUP** to exit all the setup menus.

If ever you need to check or re-adjust the antenna, repeat steps 6-11. However, with longer experience I haven't found it necessary to adjust for weather conditions at all (not even here on the Wet Coast). If the pattern or the SWR do seem to have changed, that is probably because the SteppIR element lengths have slipped; if so, the **CALIBRATE** procedure will bring everything back to normal.

And that's it – your optimized 6m SteppIR is ready. Now go and work some new ones!