



ASSIGNMENT 11 PARASITIC ELEMENTS

Objectives

When you have completed this assignment you will:

- have investigated the properties of a system comprising a dipole and a parasitic element,
- understand the terms 'driven element', 'reflector' and 'director',
- know the form of a 'yagi' antenna.

Knowledge Level

You should have performed Assignments 6 & 8.

Preliminary Procedure

Before you start you should have:

- connected up the hardware of *AntennaLab* as described in the Operator's Manual,
- loaded the Discovery software as described in the Operator's Manual,
- loaded the NEC-Win software as described in its accompanying manual,
- read the Using AntennaLab chapter in the Operator's Manual.



Introduction

In Assignment 6, the effects of the 'image' of an antenna due to ground reflections were investigated. It was shown that there is an increase in gain (in some directions) when an antenna is brought close to ground, due to the effective 'extra' image antenna.

What happens when two antennas were positioned close to each other and both driven was investigated In Assignment 8.

In this assignment, the effect of positioning a second, un-driven, real antenna close to the driven one is investigated.

Practical 11.1 Two Dipole Elements

Identify one of the Yagi Boom Assemblies and mount it on top of the Generator Tower.

Ensure that all of the elements are removed, except for the dipole, and that this is mounted above the tower support.

Ensure that the Motor Enable switch is off and then switch on the Trainer.

Launch a signal strength vs. angle 2D polar graph window and immediately switch on the Motor Enable switch.

Ensure that the Receiver and Generator antennas are aligned with each other and that the spacing between them is about one metre.

Set the dipole length to 10cm.

Acquire a new plot at 1500MHz.

Observe the polar plot obtained.

Identify one of the other un-driven dipole antenna elements that are supplied with the Antenna Systems Trainer.

Move the driven dipole forward on the boom by about 2.5cm and mount a second un-driven dipole element behind the first, at a spacing of about 5cm.



Set the un-driven dipole length to 10cm.

Acquire a second new plot at 1500 MHz.

Question 11.1.1

Has the polar pattern changed by adding the second element?

Question 11.1.2

Has the gain changed by adding the second element?

Question 11.1.3

Has the directivity changed by adding the second element?

Change the spacing between the two elements of the antenna to 2.5cm.

Acquire a third new plot at 1500 MHz.

Question 11.1.4

What changes has the alteration in spacing made to the gain and directivity?

Practical 11.2 Changing the Length of the Parasitic Element

Set the spacing between the two elements to 2.5cm and ensure the lengths of both the elements are 10cm.

Launch a new signal strength vs. angle 2D polar graph window.

Acquire a new plot at 1500 MHz.

Extend the length of the un-driven element to 11cm.

Acquire a second new plot at 1500 MHz.

Reduce the length of the un-driven element to 8cm.

Acquire a third new plot at 1500 MHz.

Question 11.2.1

What changes has the alteration in length made to the gain and directivity?



Practical 11.3 Software Simulation

Run NEC-Win and click Open File on the toolbar. Open file **dipole1**.

Check that the Y co-ordinates for the dipole are -0.05 and $+0.05$ and ensure that No Ground is set.

Click on the cell of the table that has the figure 1 in it under Wire on the left-hand column of the table. This will highlight the Wire 1 row.

Click on the Copy button on the toolbar, to copy this row to the clipboard.

Now highlight row 'Wire 2' by clicking on the 2 in the Wire column.

Click on the Paste button in the toolbar to paste into the Wire 2 row.

The second dipole must now be placed 2.5cm behind the first. Change X1 and X2 for Wire 2 to be -0.025 to do this. Verify that you have done this correctly by looking at NEC-Vu.

The second dipole is not going to be driven, so you need to remove the source from Wire 2. Click on the Src/Ld cell for Wire 2 and then drag the green source icon into the bin at the bottom right-hand corner. Then click OK.

Save this two element antenna as **2el1**.

Look at the plots for this antenna.

Now, change the length of the second dipole element (the Y co-ordinates of Wire 2) to give a total length of 11cm.

Save this antenna as **2el2**.

Look at the plots for this antenna.

Now, change the length of the second dipole to give a total length of 8cm.

Save this antenna as **2el3**.

Look at the plots for this antenna and add the 2el1 and 2el2 files. Give them different colours so that you can identify which is which.



Question 11.3.1

How do these theoretical, simulated plots compare with the 'real' plots obtained from Practical 11.2?

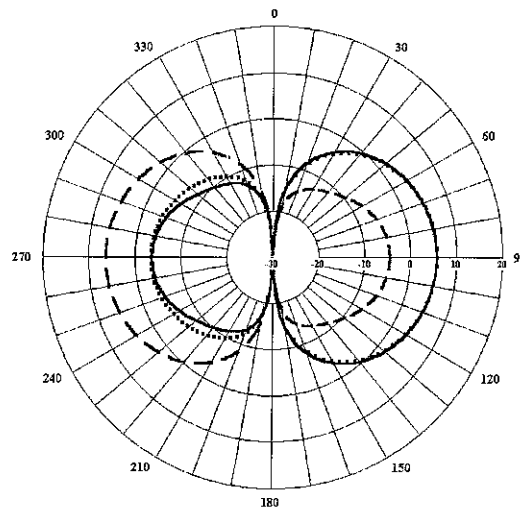


Figure 2-11-1: Typical Simulation Plots

With the length of the second dipole (the un-driven, or 'parasitic' element) shorter than the driven dipole (the driven element) the direction of maximum radiation is from the driven element towards the parasitic element. In this case, the parasitic element is called the 'director'.

With the length of the second dipole longer than the driven dipole the direction of maximum radiation is from the parasitic element towards the driven element. In this case, the parasitic element is called the 'reflector'.

An antenna of this type, with a driven element and one, or more , parasitic elements is generally known as a 'yagi', after on of its inventors (Mssrs Yagi and Uda). Assignment 12 investigates yagis in more detail.



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ASSIGNMENT 12 MULTI-ELEMENT PARASITIC ARRAYS

Objectives

When you have completed this assignment you will:

- have examined multi-element yagis,
- have seen how gain and directivity increase as element numbers increase,
- appreciate the practical limitations to the number of elements.

Knowledge Level

You should have performed Assignment 11.

Preliminary Procedure

Before you start you should have:

- connected up the hardware of *AntennaLab* as described in the Operator's Manual,
- loaded the Discovery software as described in the Operator's Manual,
- loaded the NEC-Win software as described in its accompanying manual,
- read the Using AntennaLab chapter in the Operator's Manual.



Introduction

Assignment 11 showed that the addition of a second parasitic dipole element close to the driven dipole gives rise to a change in directivity and an increase in gain in a preferred direction. It also showed that the length of the parasitic element had an effect on the direction of maximum gain. If the parasitic element is the same length, or longer than the driven element the gain is in a direction from parasitic element to driven element. The parasitic element acts as a reflector. If the parasitic element is shorter than the driven element the gain is in a direction from driven element to parasitic element. The parasitic element acts as a director.

This assignment investigates the effects of increasing the number of reflectors and directors on the gain and directivity of an array.

Practical 12.1 Adding a Second Reflector – Hardware Modelling

Identify one of the Yagi Boom Assemblies and mount it on top of the Generator Tower. See Figure 2-12-1.

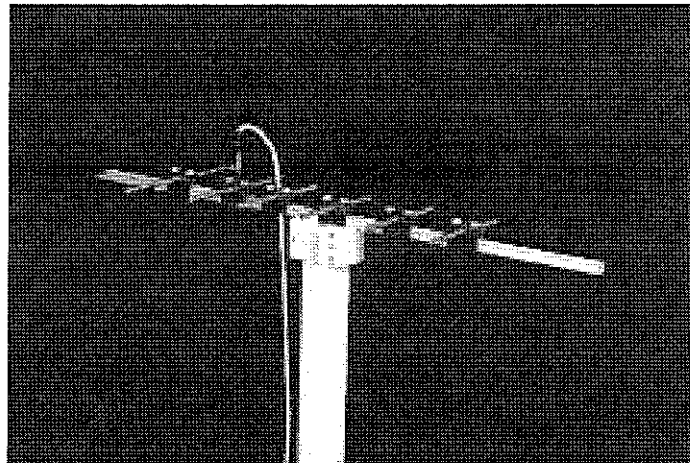


Figure 2-12-1: Multi-element Yagi Assembly

Ensure that all of the elements are removed, except for the dipole.

Ensure that the Motor Enable switch is off and then switch on the Trainer.



Launch a signal strength vs. angle 2D polar graph and immediately switch on the motor enable.

Ensure that the Receiver and Generator antennas are aligned with each other and that the spacing between them is about one metre.

Mount the driven dipole on the boom forward from the axis of rotation by about 2.5cm and mount a second un-driven dipole element behind the first, at a spacing of about 5cm.

Set the dipole length to 10cm and the un-driven dipole length to 11cm.

Acquire a new plot at 1500 MHz.

Observe the polar plot.

Mount a second parasitic element about 5cm from the first parasitic reflector and adjust its length to 11cm.

Acquire a second new plot at 1500 MHz.

Observe the polar plot.

Question 12.1.1

Is there any significant difference between the two plots?

Change the spacing between the two reflectors and acquire a third new plot at 1500 MHz.

Question 12.1.2

Is there any significant difference between the plots, now?

You will find that the addition of a second reflector has little effect on the gain and directivity of the antenna, irrespective of the spacing between the two reflectors.

Practical 12.2 Adding Directors

Remove the second reflector element from the boom.



Launch a new signal strength vs. angle 2D polar graph window.

Acquire a new plot at 1500 MHz.

Observe the polar plot.

Mount a parasitic element about 5cm in front of the driven element and adjust its length to 8.5cm.

Acquire a second new plot at 1500 MHz.

Observe the polar plot.

Question 12.2.1

Is there any significant difference between the two plots?

Move the director to about 2.5cm in front of the driven element.

Acquire a third new plot at 1500 MHz.

Observe the polar plot.

Question 12.2.2

How does the new plot compare with the previous two?

Launch another new signal strength vs. angle 2D polar graph window.

Acquire a new plot at 1500 MHz.

Add a second director 5cm in front of the first.

Acquire a second new plot at 1500 MHz.

Add a third director 5cm in front of the second.

Acquire a third new plot at 1500 MHz.

Add a fourth director 5cm in front of the third.

Acquire a fourth new plot at 1500 MHz.

Question 12.2.3

How do the gains and directivities compare?

Launch another new signal strength vs. angle 2D polar graph window.



Acquire a new plot at 1500 MHz.

Move the reflector to 2.5cm behind the driven element.
Acquire a second new plot at 1500 MHz.

Question 12.2.4

Does the driven element – reflector spacing have much effect on the gain or directivity of the antenna?

Navigate to the Return Loss vs. Frequency application page and read the instructions given.

Identify the Directional Coupler. Connect it up as detailed in the instructions for the reference power level (forward power reference).

Ensure that the directional coupler is kept as far as possible from the other equipment.

Launch a return loss vs. frequency graph window.

From the menu, click on 'File' then 'New Plot'. Accept the default frequency of 1500MHz.

The reverse power measurements may now be taken. Connect up the directional coupler as detailed in the instructions. Click 'OK' when ready to proceed.

Move the reflector to 5cm behind the driven element.

Acquire a second new plot.

Question 12.2.5

Between which frequencies is the VSWR 2:1, or less, for the 2.5cm reflector spacing?

Question 12.2.6

Between which frequencies is the VSWR 2:1, or less, for the 5cm reflector spacing?

Question 12.2.7

Does the narrow, or the wide spacing give the greater VSWR bandwidth?



Practical 12.3 Software Simulation

Run NEC-Win and click Open File on the toolbar. Open file **2el2**.

Check that the Y co-ordinates for the dipole are -0.05 and +0.05 and ensure that No Ground is set.

Check that the Y co-ordinates for the reflector are -0.055 and +0.055 and change the X co-ordinates to -0.05. This gives a 5cm spacing between driven element and reflector.

Copy Wire 2 into Wire 3 and then, for Wire 3, enter Y co-ordinates of +0.0425 and -0.0425 and X co-ordinates of +0.025, corresponding to an element length of 8.5cm and a spacing of 2.5cm between driven element and director.

Verify that you have done this correctly by looking at NEC-Vu.

Ensure that there are no sources associated with Wires 2 and 3.

Save this three element antenna as **3el1**.

Run NEC for this antenna.

Copy Wire 3 into Wire 4 and then, for Wire 4, enter Y co-ordinates of +0.075, corresponding to an element length of 8.5cm and a spacing of 5cm between the two directors.

Verify that you have done this correctly by looking at NEC-Vu.

Save this four element antenna as **4el1**.

Run NEC for this antenna.

Copy Wire 4 into Wire 5 and then, for Wire 5, enter Y co-ordinates of +0.125, corresponding to an element length of 8.5cm and a spacing of 5cm between the directors.

Verify that you have done this correctly by looking at NEC-Vu.

Save this five element antenna as **5el1**.

Run NEC for this antenna.



Copy Wire 5 into Wire 6 and then, for Wire 6, enter Y co-ordinates of +0.175, corresponding to an element length of 8.5cm and a spacing of 5cm between the directors.

Verify that you have done this correctly by looking at NEC-Vu.

Save this six element antenna as **6el1**.

Run NEC for this antenna.

Click on the Pattern Plot button and then add the **3el1.nou**, **4el1.nou** and **5el1.nou** files.

Select the azimuth plots and superimpose them, choosing different colours for each.

Question 12.3.1

Do the software plots agree, generally, in shape with those modelled with the hardware?

Question 12.3.2

How do the gains and directivities compare?

Now, select the elevation plots and superimpose them, choosing different colours for each.

Question 12.3.4

Are the plots as directive in the elevation plane?

Generally, as the number of elements goes up so does the forward gain and the directivity. However, there is a diminishing return. In practice, the increase in gain from a dipole to a 2 element yagi is just less than 3dB. Adding a director to make a 3 element yagi generally increases the gain by about 2dB. Another director to make a 4 element yagi will perhaps give another 1dB, and so on.

Theoretically, doubling the number of elements should double the gain (+3dB). In practice this is never achieved – perhaps 2dB or 2.5dB only.



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