Antenna Optimization

Yagi-Uda

Introduction

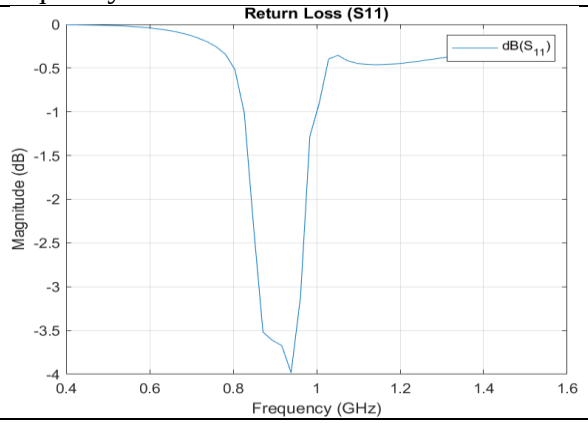
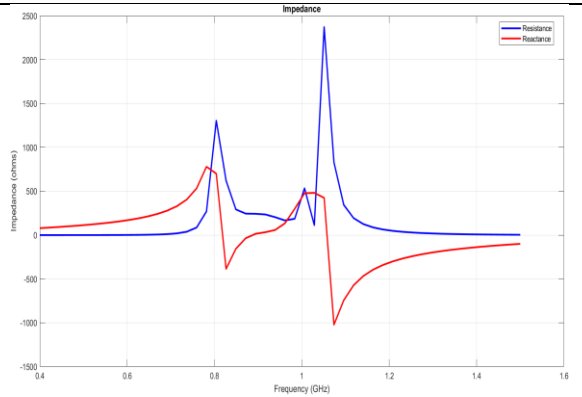
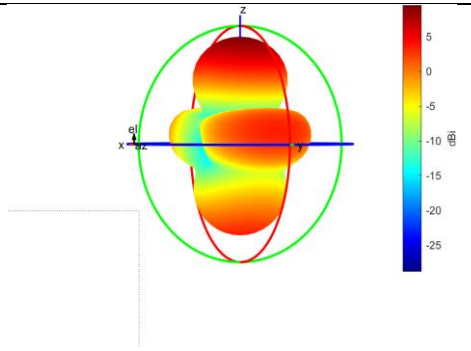
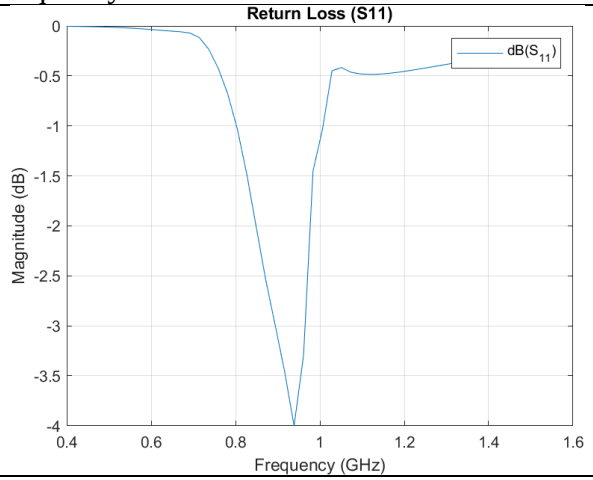
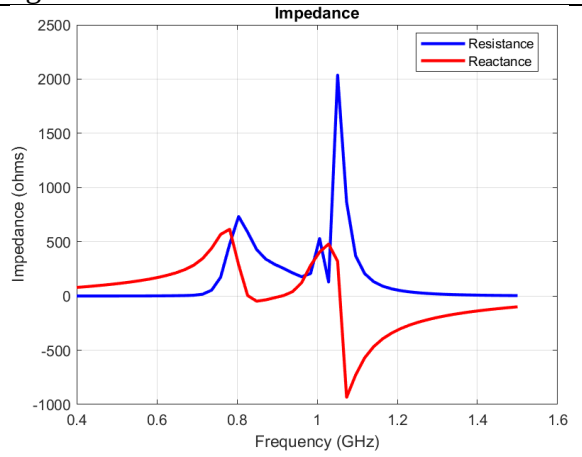
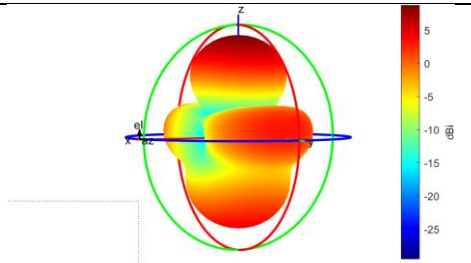
The Yagi Uda Antenna is primarily meant for high directivity pattern uses, meaning it requires the gain to be significantly focused in one direction instead of any other.

The set *reference* values for viewing the deviation from *baseline* of the antenna characteristics are:

- Reflector Spacing (RS)= 0.25lambda
- Reflector Length (RL)= 0.55lambda
- Director Spacing (DS)= 0.2lambda (1 1 1)
- Director Length (DL)= 0.45lambda (1 1 1)

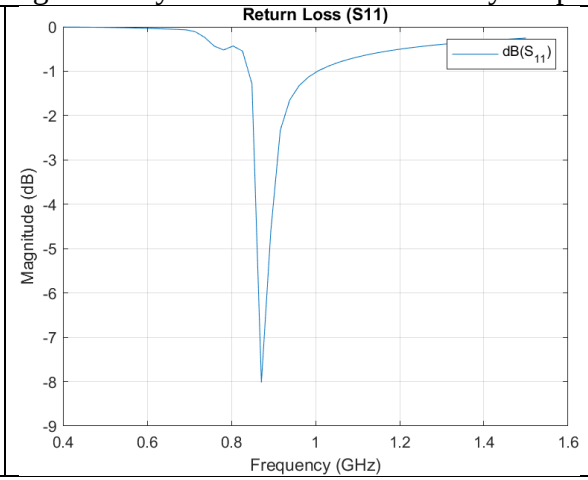
The Exciter is a folded dipole and there are 3 directors aligned in front of it and one reflector behind it.

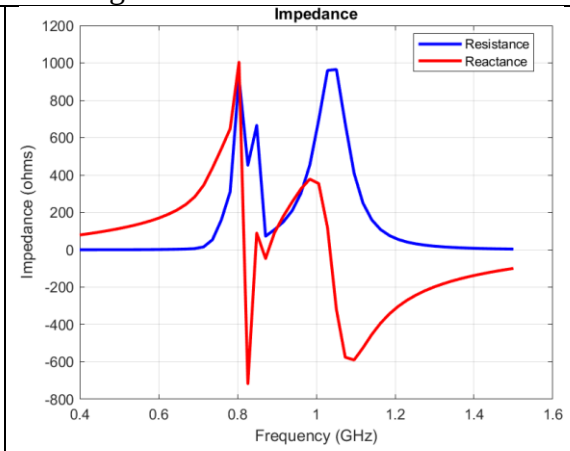
Observation

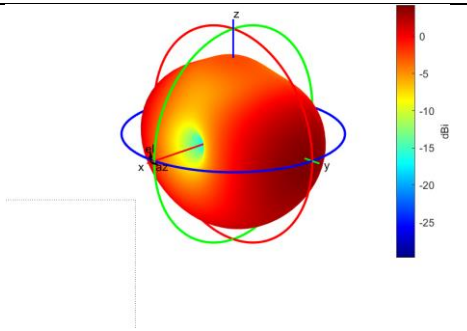
	S11-Reflection Coefficient/ Return Loss	Z-Impedance	Pattern
All parameters constant. There is significant gain with large back lobe suggesting ineffective reflector. Large side lobes suggest poor directivity offered by directors Resonant frequency is at 920MHz			
Original Gain= 9.45dB -28.9dB			
Only reflector length increased making it much larger than the directors. Directivity decreases slightly, indicated by the slightly weaker main lobe and stronger side lobes Makes directors more ineffective Resonant frequency is same at 920MHz with same matching			
RL=0.65 Gain= 8.71dB -21.5dB			
Both director and reflector lengths are increased Gain and directivity fall with much stronger sidelobes and weak main lobe and back lobe The directors are more ineffective but the reflector is more effective			

There is a significantly better match indicated by deepest S11 magnitude.

RL=0.65
DL=0.55
Gain=
4.15dB
-21.8dB

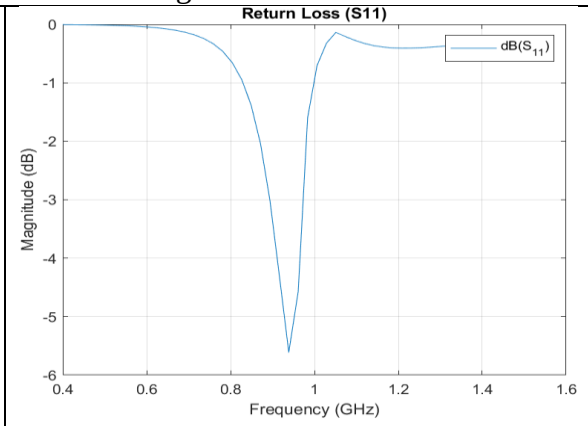


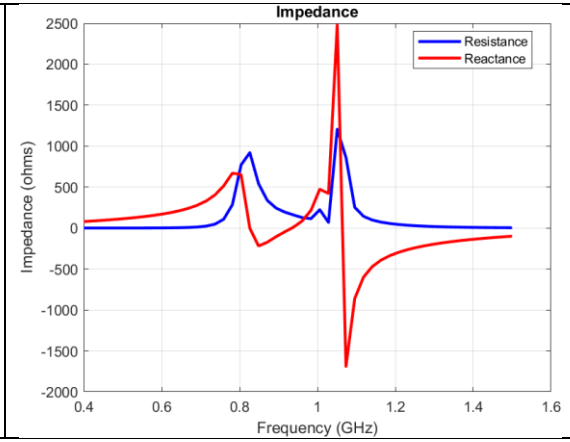


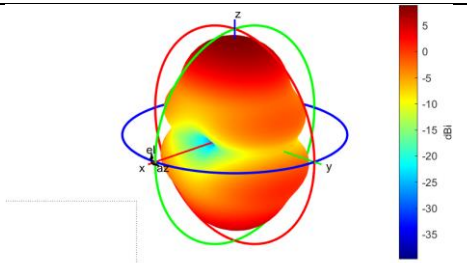


Only Reflector length is reduced to 0.45 equaling the director lengths
The Back lobe is stronger equaling the main lobe, so reflector is completely insignificant
Effective directors on account of weaker side lobes
Match is better than original

RL=0.45
Gain =
8.8dB
-39.7dB



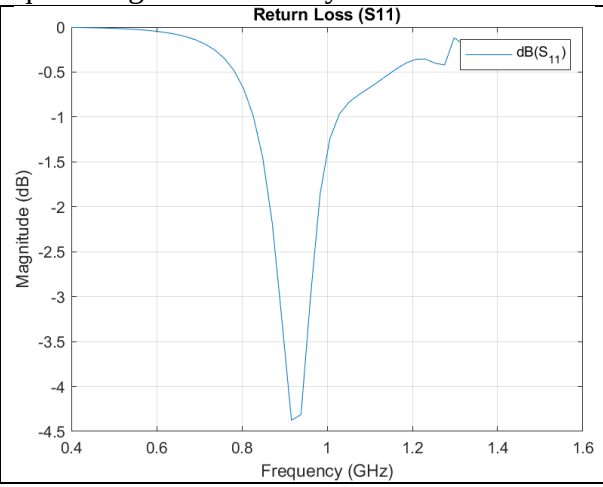


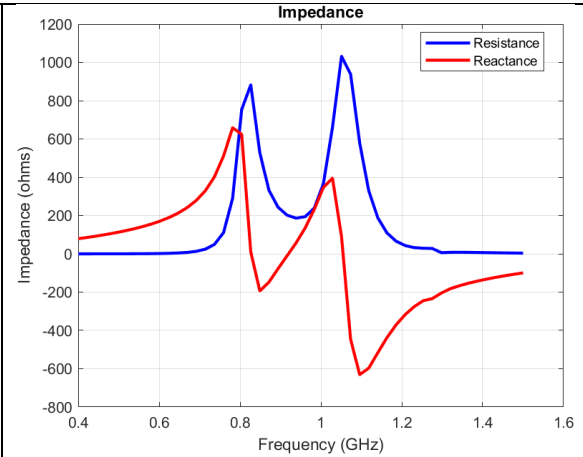


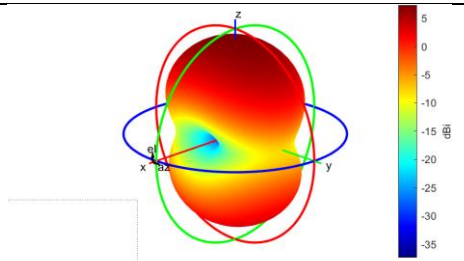
Both the Reflector and Director lengths are reduced
The are no side lobes thus very effective directors

Strong back lobe thus less effective reflector
Matching equals original reflectivity

RL=0.45
DL=0.35
Gain=7.26dB
-37.4dB

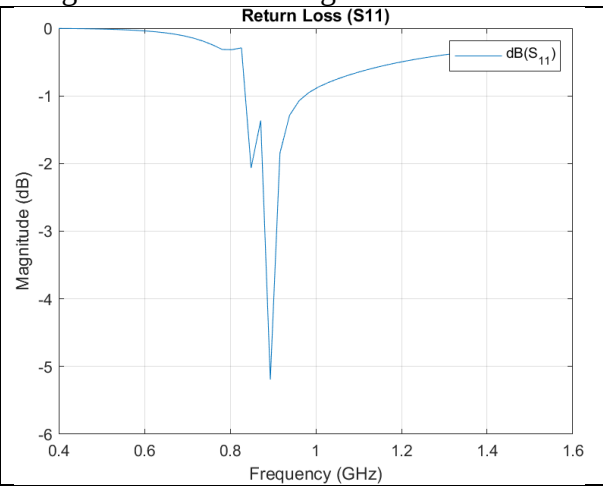


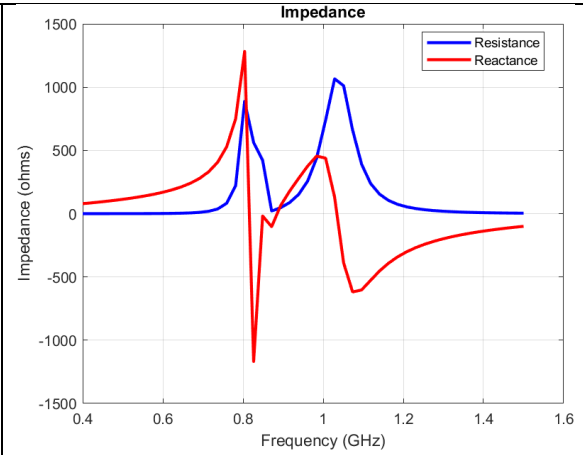


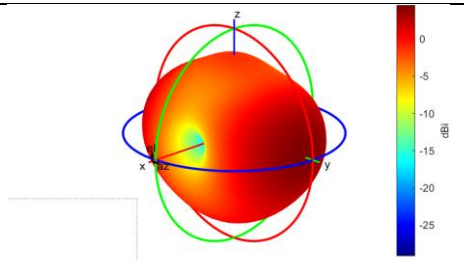


Only Director lengths increased
Side lobes are strongest thus poor directivity
Back lobe is equally as weak as main lobe
Better matching resonance than original

DL=0.55
Gain=4.49
-29.2

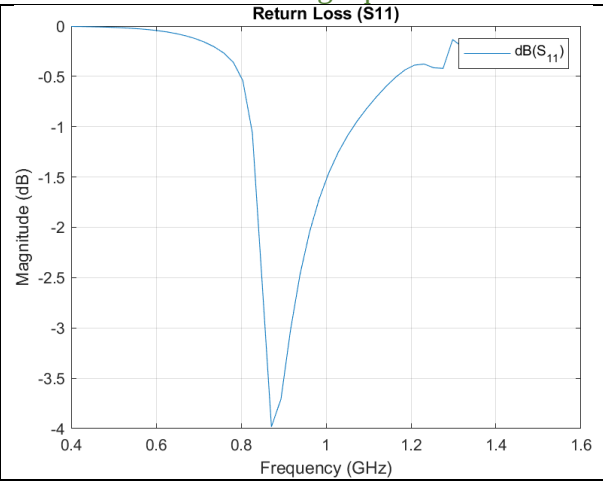


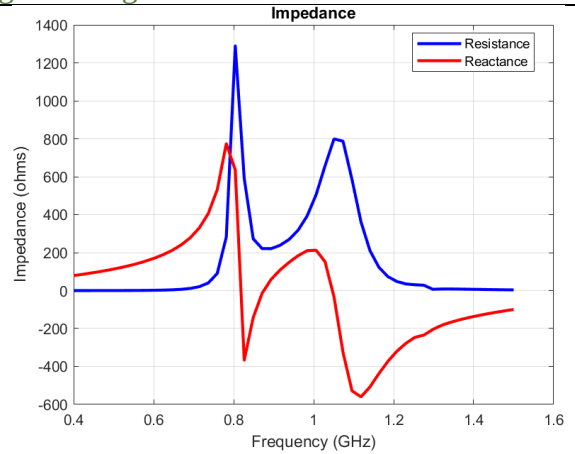


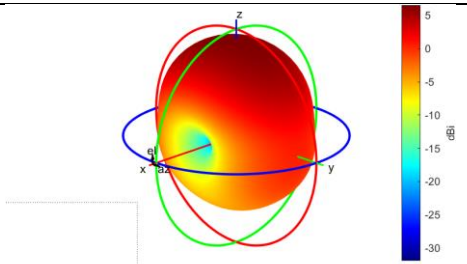


Only the Director Lengths are reduced
This offers the best pattern designated for Yagi-Uda operation
The side lobes are eliminated, the back lobe is at its least gain
It offers the best directivity meant for the antenna's use. The gain is lesser than initial but still substantial.
The reflection coefficient/ matching equals that of the original design

DL=0.35
Gain= 6.46dB
-31.9dB

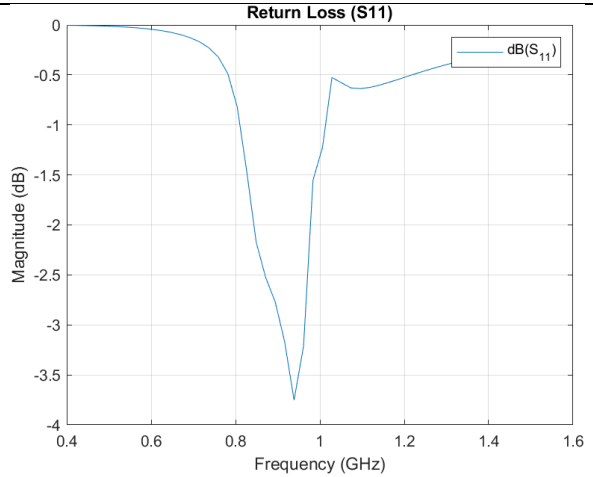


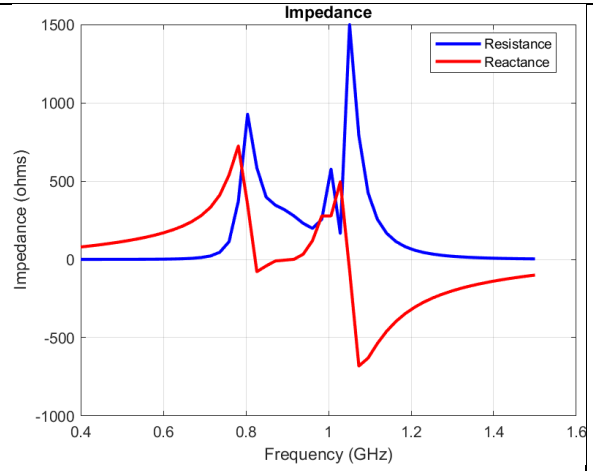


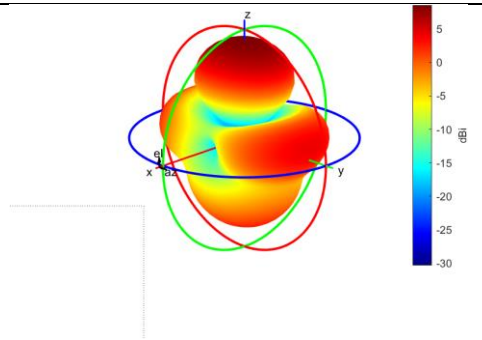


Only the reflector spacing is increased
Gain remains significant. Side lobes are strongly present along with a strong back lobe so ineffective reflector and directors.
Matching is reduced

RS=0.35
Gain=
8.47dB
-30.3dB

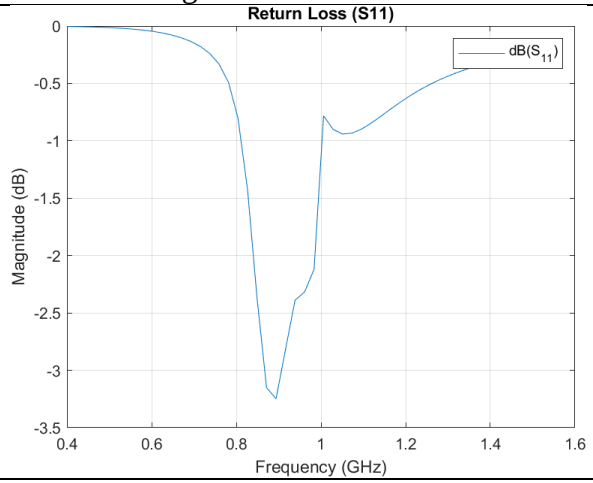


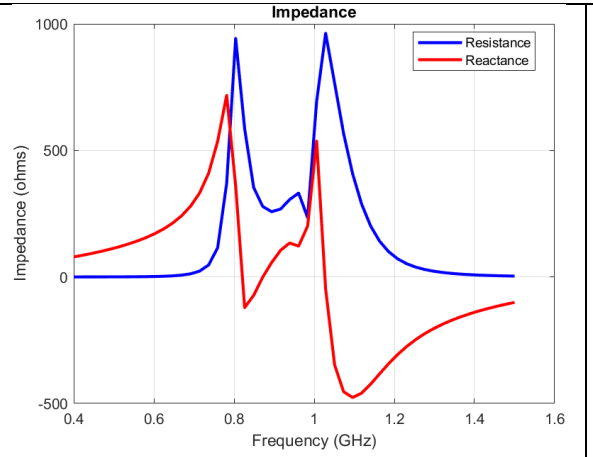


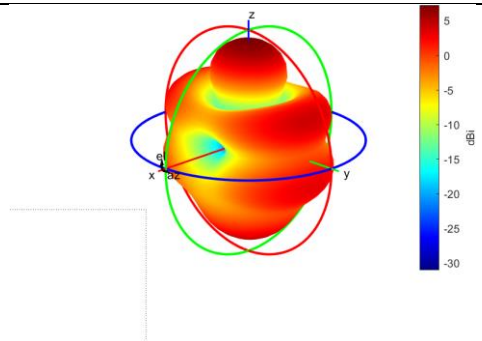


Both the reflector and the directors spacings are increased
Strong gain but minor lobes are still strong meaning ineffective reflector and directors
Increased sidelobes sizes and number
Has even worse matching

RS=0.35
DS=0.3
Gain=
7.2dB
-31dB







Only the reflector spacing is reduced

Has the highest gain recorded

Though present, the back lobe is significantly weaker

Sidelobes still present thus directors are not too effective

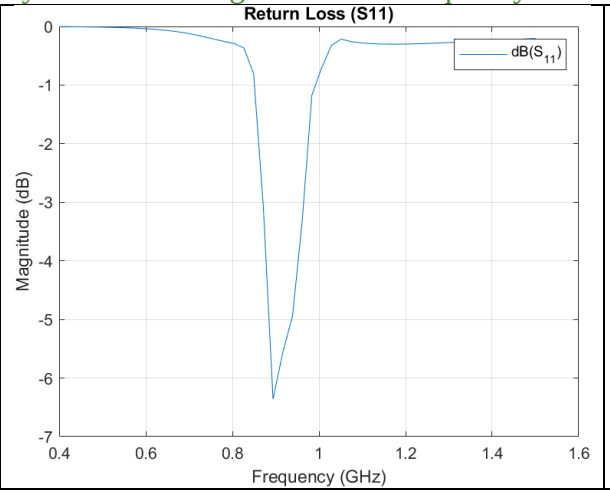
Significantly better matching at resonant frequency

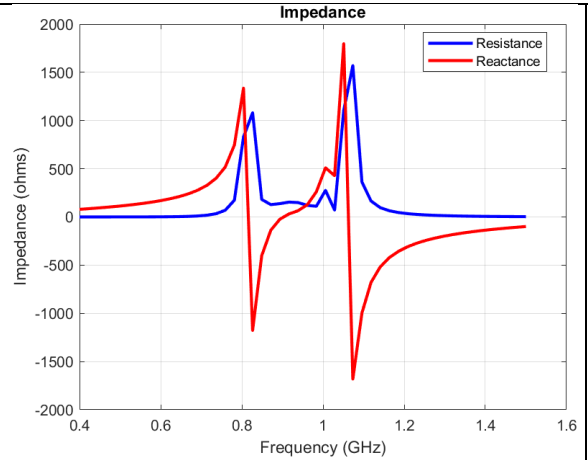
RS=0.15

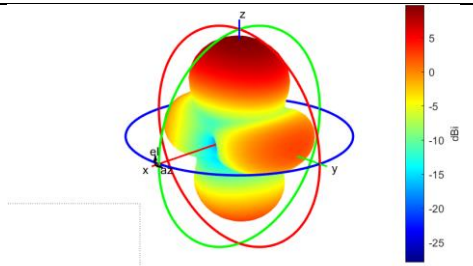
Gain=

9.76dB

-27.9dB





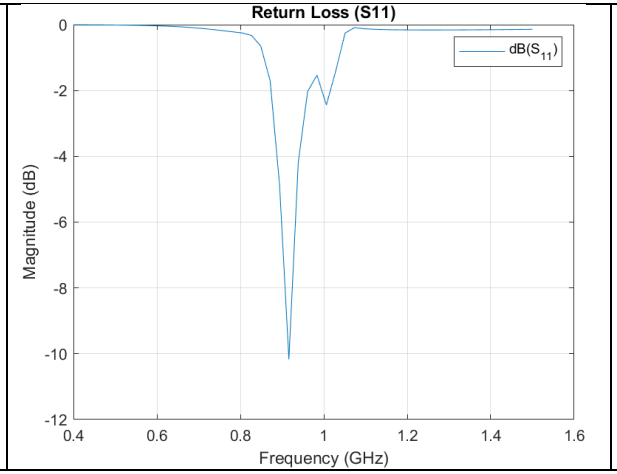
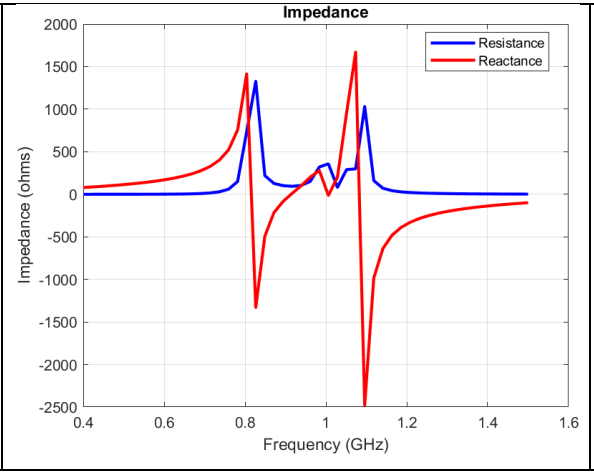
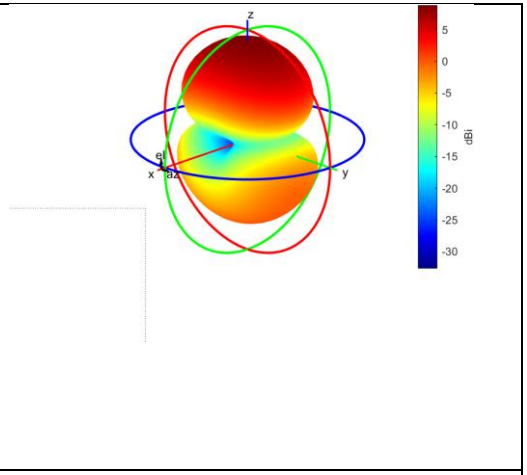
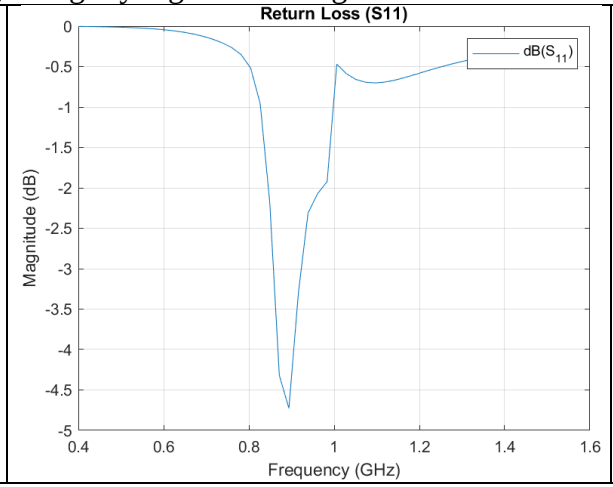
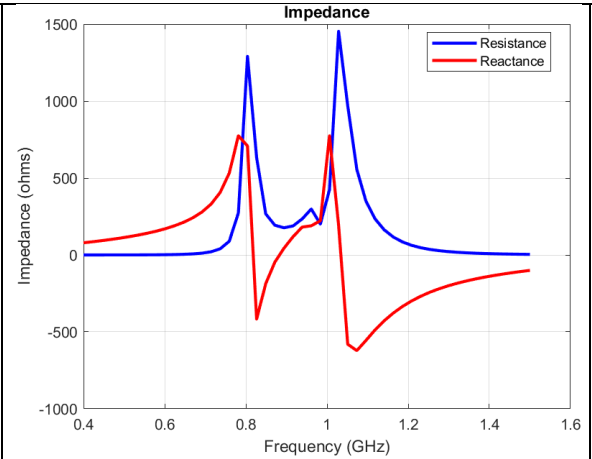
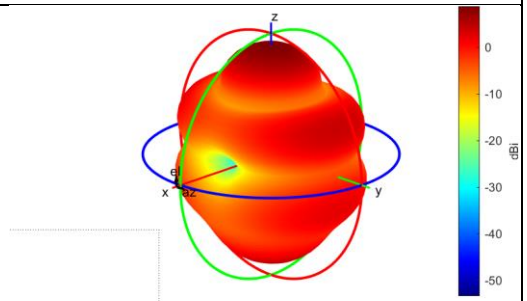


Both Reflector and Directors spacings are reduced

Strong gain, with no side lobes meaning effective directors

Back lobe still strong indicating ineffective reflector

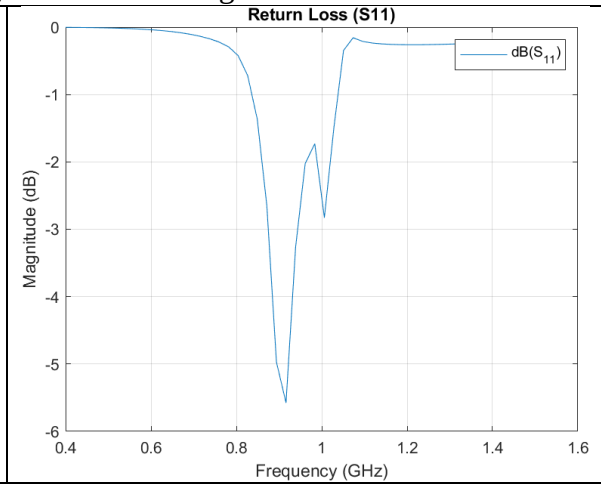
Offers the best matching at resonant frequency

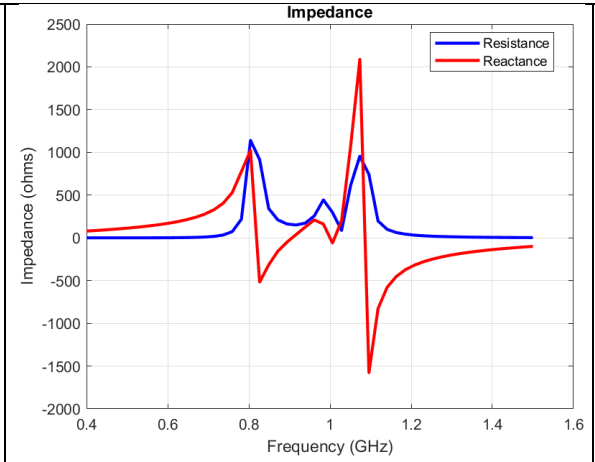
RS= 0.15 DS=0.1 Gain= 8.76dB -32.7dB			
Only Directors spacing increased The worst patter with worst directivity though high gain Ineffective directors and reflector since minor lobes are just as strong as main lobe Matching is slightly higher than original.			
DS=0.3 Gain= 8.66dB -53.4dB			
Only directors spacings are reduced There are no sidelobes meaning effective directors			

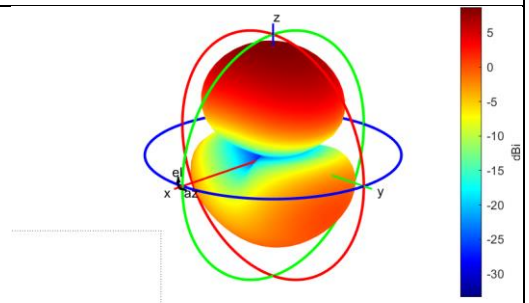
Strong gain but also strong back lobe so ineffective reflector
Matching is better than original

DS=0.1
Gain=

8.66dB
-33.4dB



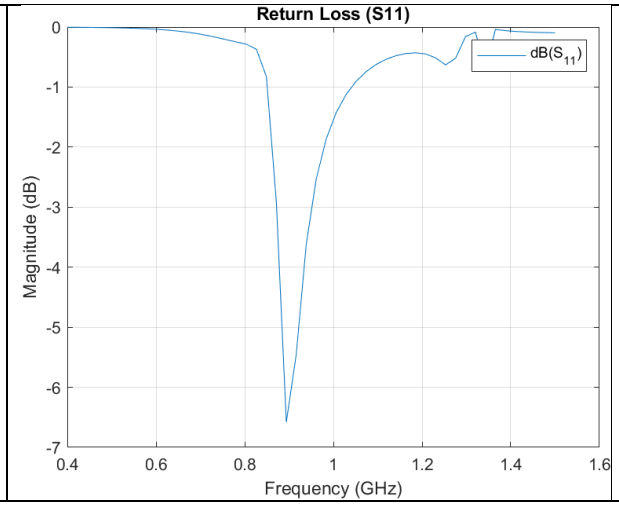


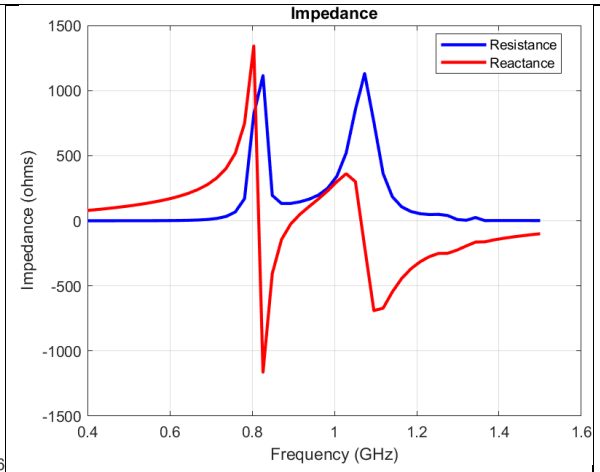


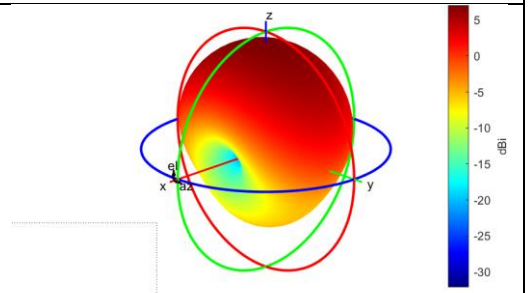
Best Compilation of Characteristics
Director Length, Reflector and Director spacing are all reduced. Only Reflctor length isn't changed.

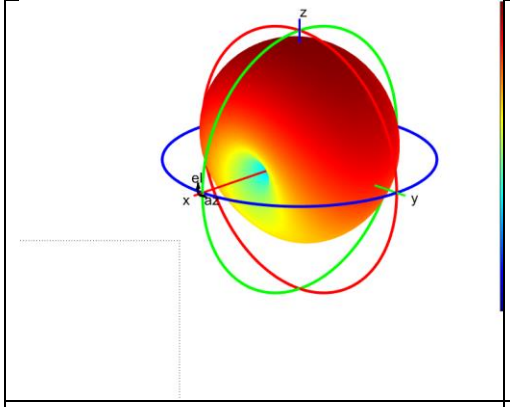
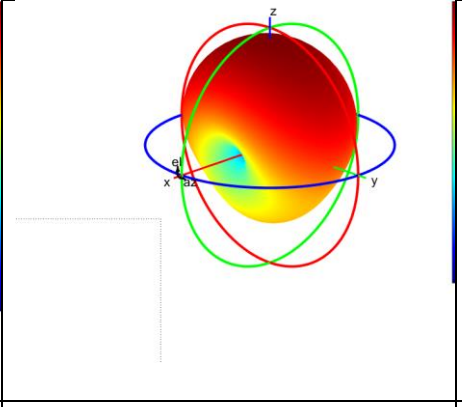
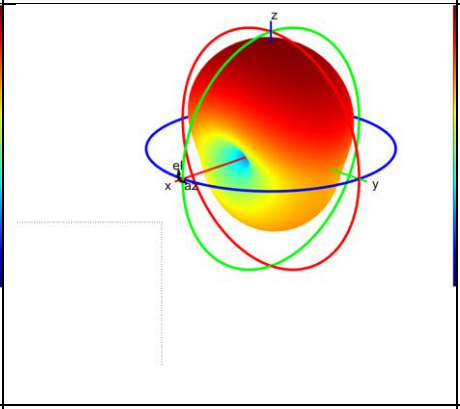
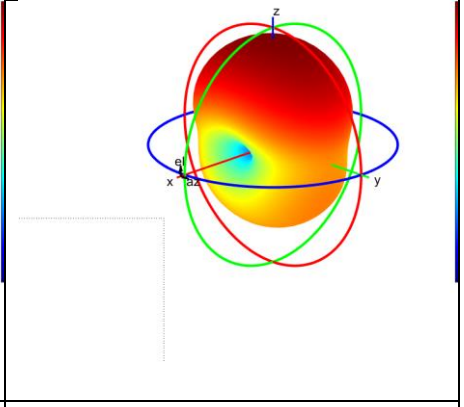
DL=0.3
5
RS=0.15
DS=0.1

Gain =
6.97dB
-32.1dB

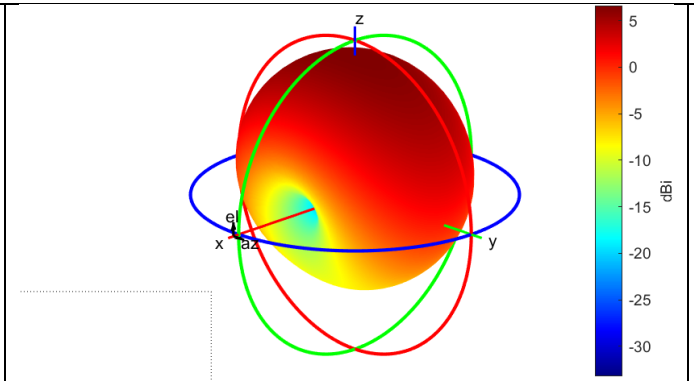
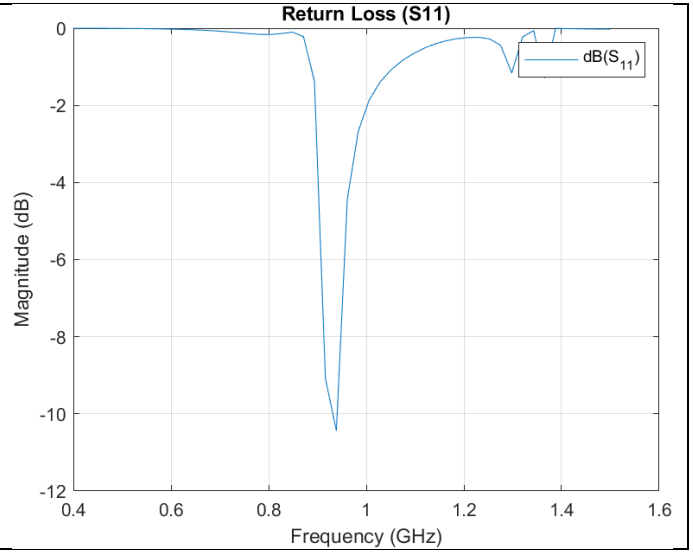






2 Directors	3Directors (OG)	4 directors	5 Directors
			
Gain=6.28dB =-32,3dB	Gain=6.97dB =-32.1dB	Gain=7.41dB =-31.9dB	Gain=7.64dB =-31.7dB

For next consideration on optimization, how to thin out the main lobe

G=6.53dB =-33.2dB RS = 0.15 DS = 0.05		

Discussion

The resonant frequency always falls at 920MHz, so this is the operating frequency for the Yagi Uda antenna.

Increasing the director lengths at any instance proves detrimental to the pattern, to gain and to directivity. It results in minor lobes stronger than the main lobe, consistently. Nonetheless, it results in better matching since the reflection loss is lesser with its increase.

Increasing reflector length never results in effective elimination of the back lobe. Nonetheless, reducing it does seem to have a significant impact either. When assembling ideal parameters, the reflector length is not tampered with since increasing it offers no change to the pattern but reduces impedance matching but decreasing it strengthens the back lobe.

The best pattern is contributed to by decreased director length. It is the only pattern with most effective elimination of back lobe.

The best matching with least reflection loss is contributed to by reducing both director and reflector spacing. This is the only combination that appear to reduce the back lobe.

The highest gain is recorded by reducing only the reflector spacing

Director spacing if increased increases sidelobes but if reduced eliminated them completely.

The spacing of the directors or reflector, contribute more directly to the impedance matching, with higher matching at lesser spacings and vice versa. Despite any changes in them, the gain still remains high.

With those parameters established, when the number of directors is varied, there is minimal to no impact on the impedance matching. Nonetheless, an increase in directors increases overall gain and vice versa. If the directors are too many, the create a back lobe.

Note: Despite any drastic changes in the other parameters, the antenna seems to only always operate better when the reflector length is never changed but maintained at 0.55lambda. as these other parameters, when they are reduced further past a particular threshold, the pattern returns to a circular shape with no distinct lobes but somewhat omnidirectional transmission. Further reduction of director length is counterproductive, however, further reduction of the reflector and director spacing increases the impedance matching significantly and completely eliminates the back lobe. It only now brings the new challenge of lowering directivity and gain of main lobe, rounding it out as if a continuous combination of the contiguous sidelobes and the main lobe

Note: If director length ever equals or is greater than reflector length, a large back lobe forms. Also, if director length values ever relatively far exceed the spacing values, a rift forms creating a large back lobe and main lobe. And recall, is the director length is reduced too much, the pattern rounds out with no main lobe. Meanwhile, reducing the spacing values further reduces the back lobe. Keeping that in mind, there will be a limitation to how much the values of spacing and director length can be reduced.

Conclusion

The best Yagi Uda antenna consists of a director length significantly reduced with respect to the reflector length, and both the reflector and director spacings being reduced.

In this case the ideal values now are:

- Reflector Spacing (RS)= 0.15lambda -- Reduced
- Reflector Length (RL)= 0.55lambda -- Unchanged
- Director Spacing (DS)= 0.1lambda (1 1 1) -- Reduced

- Director Length (DL)= 0.15lambda (1 1 1) –Reduced
- Directors = 4