18 turn Helical Antenna

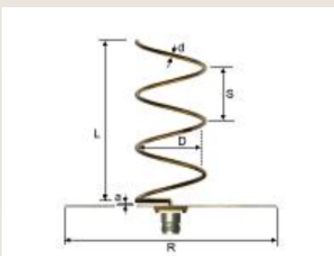
DESIGN CALCULATIONS:

Helix antenna design and construction details

Input data (design requirements)

Design frequency	2400	MHz
Number of turns	18	
Turn spacing	0.15	wavelengths
	Calculate	

The results



Legend. The letters in the image are used in the table below.

To get a large version, click on the image.

Wavelength		125	mm
Ideal diameter (internal)	**D=**	43.9	mm
Gain		18.67	dBi
Conductor diameter	**d=**	2.5	mm
Winding step (between centers)	**S=**	18.7	mm
Separation of the adapter section	**a=**	1.2	mm
Total conductor length		2509	mm
Minimum reflector diameter	**R=**	77.5	mm
Total antenna length	**L=**	337.5	mm

Frequency and Wavelength

From f=2.4 GHz ⇒ λ=125 mm

C=f λ

3*10^8 / 2.5*10^9=0.125m

Circumference (C):

- C=πD=π×0.0439=0.1379 m

Wire Length (along the helix):

- Each turn length=$\sqrt{(C^2+S^2)}$
- Total wire length=$N\times\sqrt{(C^2+S^2)} \Rightarrow 18\times\sqrt{(0.1379^2+0.01875^2)}=2.505$ m

Reflector Parameters

- **Reflector Diameter(d)** = 77.5 mm = 0.0775 m
- **Radius=77.5/2=38.75mm=0.03875**
- $Rr/\lambda=0.03875/0.125=0.31\lambda$
- **Acceptable** (axial mode needs $\geq 0.25\lambda$)
- I have implemented this as a **radial disc with 24 wires** forming a circular sheet.
- Angular spacing= 360/24=15 deg

Winding Step S

$\Lambda=0.125$m
$S=0.15\lambda=18.75$ mm
This is the vertical distance between turns, and used in GH card.

Diameter D
Given: D=43.9 mm, thus radius = 21.95 mm , I used in simulation is 22mm or 0.022 which is approximate of 21.95mm
The GH card uses this for circular path radius.

Total Height L
$L=18\times18.75=337.5$ mm
Used in GH card as Z-axis height of helix.

Number of turns:

$$\text{Turns} = \frac{L}{S} = \frac{0.3375}{0.0187} \approx 18$$

GAIN CALCULATION:

Kraus Gain Formula for Helical Antenna (Axial mode)

$G\approx 10\log_{10}(15NC^2S/\lambda^3)$

Where:

- $N = 18$ turns
- C = circumference = $\pi \times D \approx \pi \times 43.9 \approx 137.8$ mm
- $S = 18.7$ mm
- $\lambda = 125$ mm
- $G \approx 10\log_{10}(15NC^2S/\lambda^3)$

$G=10\log_{10}(15\times18\times(137.8)^2\times18.7/(125)^3)=16.9\text{dBi}\approx17\text{ dBi}$

In the simulation, a gain of **18.8 dBi** was achieved, primarily due to the effect of the **reflector (disc with radial wires)** enhancing the forward radiation.

Pitch Angle Calculation

Pitch angle (α) determines the steepness of the helix:

$\alpha=\tan-1(S/C)=\tan\text{-}1(\frac{0.01875}{0.1379})=7.7$

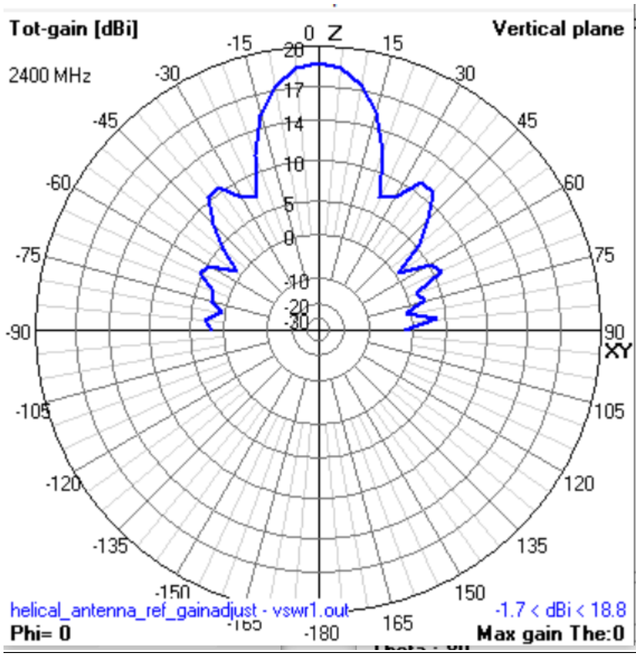
Acceptable axial mode range: $8^\circ - 14^\circ$

Slightly below the ideal axial mode pitch angle range (8°–14°), but **still acceptable.**

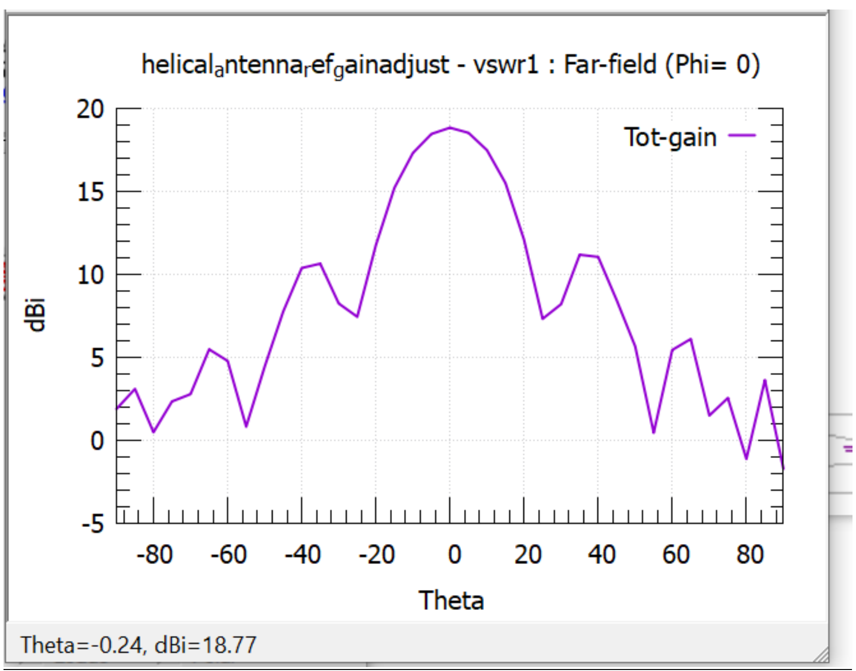
REFLECTOR

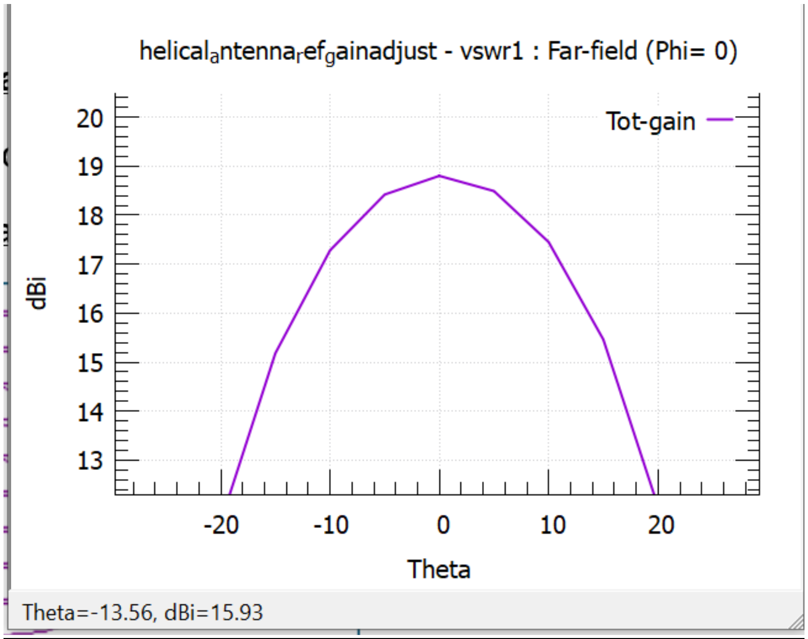
Parameter	Value
Number of Radials	24
End Points	Distributed uniformly around circle
Wire Radius	0.001 m = 1 mm
Wire Segments	5 segments per radial
Feature	**Purpose**
24 radial wires	Approximates circular ground disc
Radius = 38.75 mm	Just over λ/3 (good for reflector)
Lies in XY-plane	Reflects signal upward
Improves gain	More directivity and higher F/B ratio

RESULTS:



2D RESULTS:



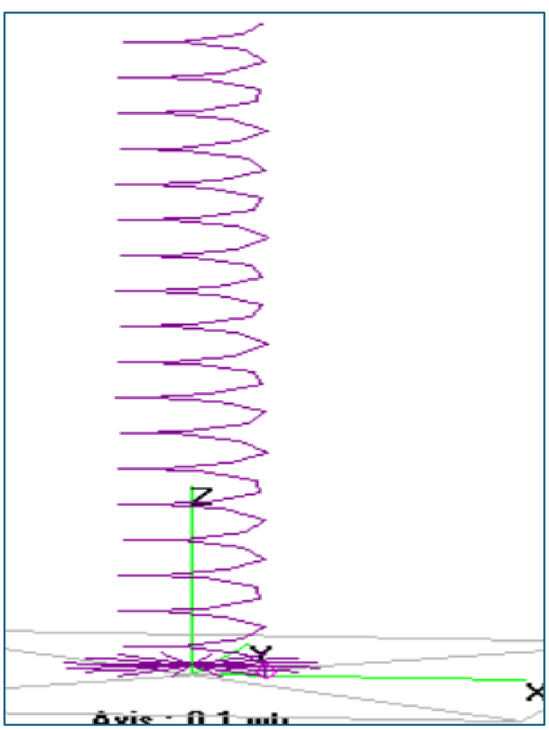


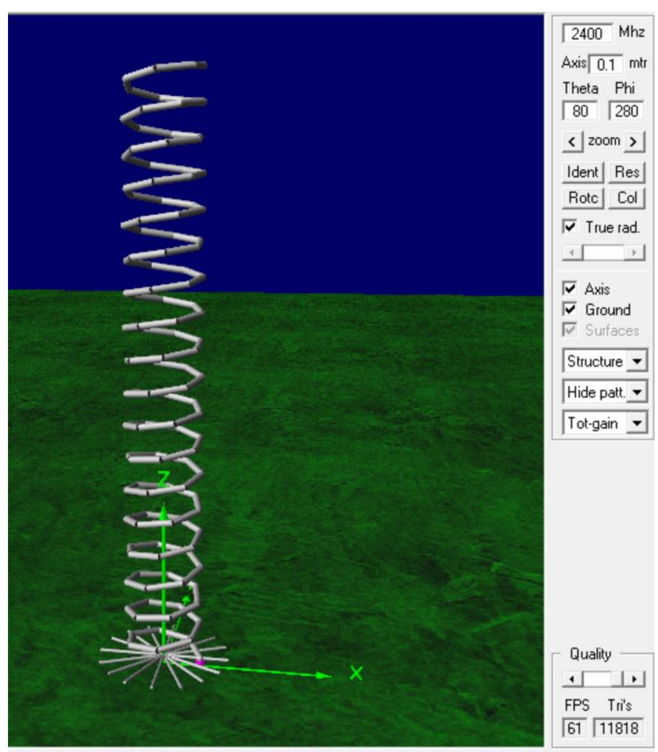
For 3dB beam width

Max gain -3dB= 18.8-3=15.8

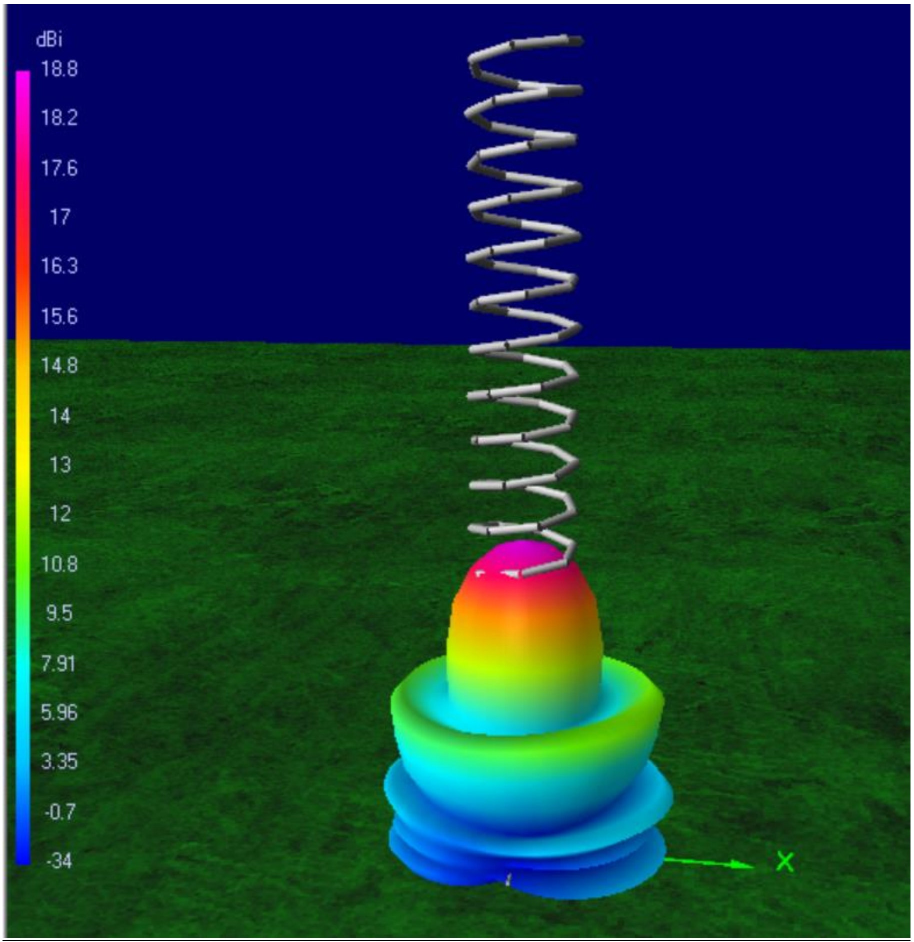
3 db beamwidth= 2x13=26 degree

3D antenna structure:





RADAITION PATTERN:



Conclusion

The designed helical antenna operates effectively in axial mode at 2.4 GHz. The helix has 18 turns, a circumference of 1.10λ, and a turn spacing of 0.15λ, resulting in a pitch angle of 7.75°. A gain of approximately 17 to 18 dBi is achieved suitable for directional communication systems. The full disc reflector, modeled with 24 radial wires of 0.03875 m length, provides adequate rear radiation suppression.