Project Report

ON

“RHCP and LHCP Helical Antenna design for GMRT polarization calibration and testing”.

SUBMITTED BY,

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GIANT METERWAVE RADIO TELESCOPE

ACKNOWLDGEMENT

I would like to express my sincere gratitude to Tata Institute of Fundamental Research, GMRT and NCRA for providing me with the opportunity to work on the project ‘RHCP and LHCP Helical Antenna design for GMRT polarization calibration and testing’. This project report represents the culmination of my efforts and the valuable guidance and support I received throughout the project.

I am deeply grateful to my project guides, Mr. Suresh Kumar and Mr. Sanjeet Rai, for their expertsupervision, insightful feedback, and constant encouragement. Their knowledge and expertise in the field of RFI have been instrumental in shaping this project and enhancing my understanding of the subject.

I would also like to extend my thanks to all the staff members and researchers at Tata Institute ofFundamental Research, GMRT, and NCRA for their assistance and cooperation during the project.Their inputs and discussions have greatly enriched my learning experience.

Lastly, I would like to express my heartfelt appreciation to all the individuals who directly or indirectly contributed to the successful completion of this project. Their contributions, whether bigor small, have played a significant role in shaping this report and the overall outcome of the project.

Thank you.

ANURAG VILAS WANKHEDE

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ABSTRACT

This project report presents the design and optimization of wideband Right-Hand Circularly Polarized (RHCP) and Left-Hand Circularly Polarized (LHCP) helical antennas using HFSS Ansys software for polarization calibration and testing at the Giant Metrewave Radio Telescope (GMRT). Wide bandwidth and circular polarization are crucial for effective communication, particularly in helical antennas operating in axial mode. Leveraging HFSS Ansys, this study explores design parameters to enhance bandwidth and maintain circular polarization characteristics in axial mode helical antennas. Through simulations and optimizations, adjustments to helical geometry and feed structure are investigated. The proposed wideband antennas aim to improve communication systems within GMRT environments, where reliable polarization calibration and testing are essential. By enhancing bandwidth, circular polarization, and considering axial mode operation, this research contributes to improving GMRT's polarization calibration and testing procedures, bolstering the reliability of radio astronomical observations over a wider frequency range.

Index Terms—Helical Antenna, Axial Mode, Circular Polarization, Ansys HFSS.

INTRODUCTION TO GMRT

The Giant Metre-wave Radio Telescope (GMRT) enables an unique visionary for studying the astrophysical phenomena at low frequencies of an approximate range of about 40 MHz to 1450 MHz This includes pulsars, the environments of supermassive black holes and accretion disk physics atomic, molecular and ionized gas in the Milky Way and other galaxies, jets and lobes from active galactic nuclei (AGNs), complex organic molecules, protoplanetary disks, solar and planetary emission, the epoch of reionization galaxy clusters, the cosmic microwave background ,etc. GMRT was designed and built in India by NCRA-TIFR as a national project at a low cost of about 15 million US$. With 30 antennas having a baseline of about 25 km, each antenna having a diameter of 45 metres in the array telescope operating at metre wavelengths collectively, that is the largest in the world in these frequencies. Half of the antennas are randomly located in a central one square km. area and the remaining once along the three 14 km arms of a ‘Y’ configuration. The longest baseline is about 26 km and the shortest is about 100 m. GMRT is located near Khodad Village, 80km north of Pune city.

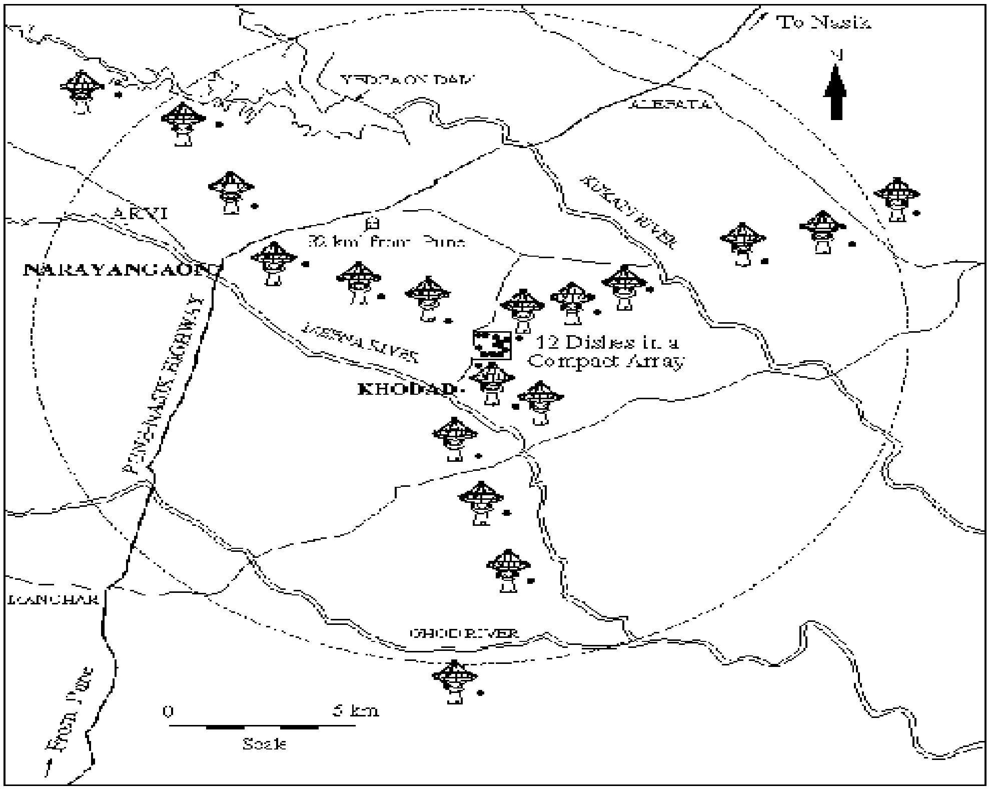


Fig 2: Some GMRT Antennas

The GMRT antenna is an alt-azimuthal mounted dish. The basicshape is formed by the 16 parabolic frames in the dish. The reflecting surface consists of a “Stretched Mesh Attached to Rope Trusses” (SMART).

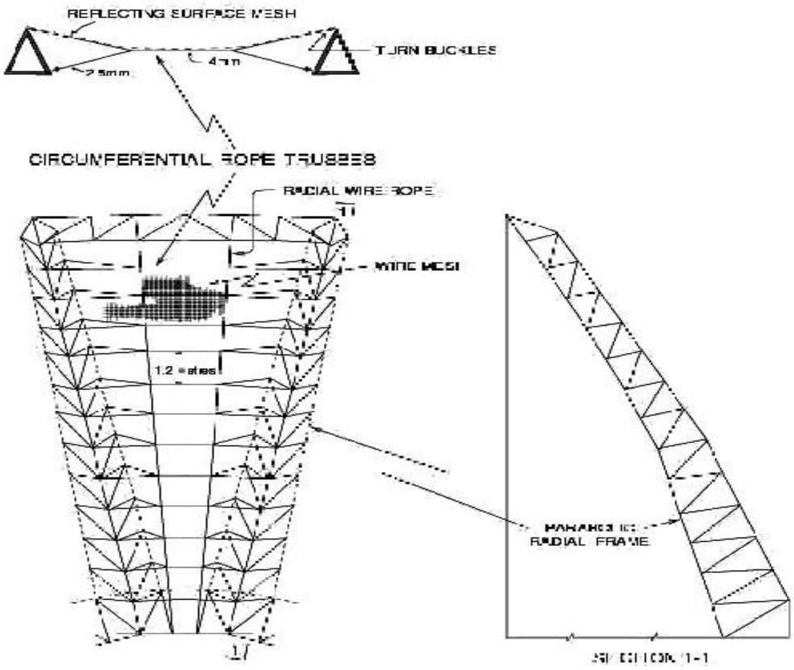


Fig 3: SMART

The wire mesh is matched to the large wavelengths of operation and varies from 10mm x 10mm inside to 20mm x 20mm in the outer one third of the dish surface which results in the efficiency variation from 60% below 1 GHz to 40% at 1.4 GHz. The GMRT operates as an "Earth-Rotation Synthesis Radio Telescope". The high sensitivity andangular resolution of GMRT are at metre and decimetre wavelengths which make it a unique instrument for studying a wide and variable range of astrophysical phenomena. There are no other telescopes existing or already planned which allows such an extensive coverage of low frequency spectrum. The multiplication or correlation of radio signals from all the 435 possible pairs of antennas or interferometers over several hours will thus enable radio images of celestial objects tobe synthesized with a resolution equivalent to that obtainable with a single gigantic dish 25 kilometers in diameter. The array will operate in four frequency bands. All these feeds provide dual polarization outputs. In some configurations, dual-frequency observations are also possible. The highest angular resolution achievable will range from about 60 arcsec at the lowest frequencies to about 2 arcsec at 1.4GHz. The dish has been made light-weight and of low solidity by replacing the conventional back-up structure by a series of rope trusses stretched between 16 parabolic frames made of tubular steel. The low-solidity design cuts down the wind forces by a large factor and is particularly suited to Indian conditions where there is no snowfall in the plains. The overall wind forces and the resultingtorques for a 45-m GMRT dish are similar to those for only a 22-m dish of conventional design, thus resulting in substantial savings in cost. The dish is connected to a `cradle' which is supported by two elevation bearings on a yoke placed on a 3.6 m diameter slewing-ring bearing secured on the top of a 15-metre-high concrete tower.

The antenna dishes can give declination coverage of -55º to +90º. Therotation of turrets at the prime focus helps to rotate the feeds for changing the frequency bands. The available feeds are in the 151,325,610/235 and the 1000-1430 MHz band. The important sub- systems of the GMRT includes Servo, Mechanical, Antenna feeds, Optical fibre sub-systems, Telemetry sub-system, Analog receiverchain, Control and Monitor data processing chain. The large size of the parabolic dishes implies that GMRT will have over three times thecollecting area of the Very Large Array (VLA) in New Mexico, USA which consists of 27 antennas of 25 m diameter and is presently the world's largest aperture synthesis telescope operating at centimeter wavelengths. At 327 MHz, GMRT will be about 8 times more sensitive than VLA because of the larger collecting area, higher efficiency of the antennas and a substantially wider usable bandwidth because of the low level of man-made radio interference in India.

• Scientific Results from GMRT

The studies at GMRT are mainly focused to observe a variety of astrophysical objects such as stars, sun, planets, Interstellar objects, Interplanetary Objects, Pulsars, extra galactic Supernova remnants, HII regions, Gamma-ray burst afterglows, Damped Lyman-alpha systems, HI absorption systems, Normal and Radio galaxies, Quasars, Cosmic Masers and Multi-field systems.

For an instance, Sun is being observed using the GMRT in all the frequency bands.

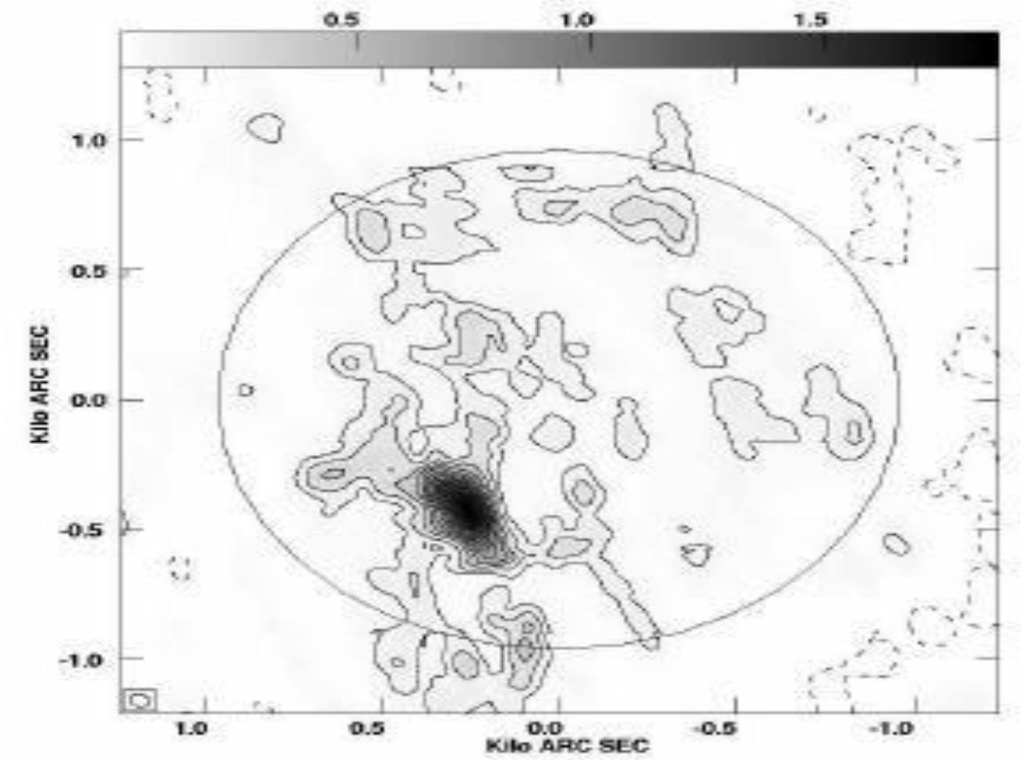


Fig 4: GMRT 150 MHz radio map of the Sun

Recently, a 150 MHz observation of the radio counterpart of a Coronal Hole was conducted where a high dynamic range synthesis map was obtained and a comparison with EUV maps shows that the Coronal Hole radio layer lies well below the X-ray and EUV layer and is useful for studying the structure of Coronal holes.

For a second instance, a new pulsar has been discovered. It is a millisecond Pulsar in a binary system with the highest known eccentricity of 0.88. This makes the apparent period of the pulsar change rapidly over the binary orbit.

Due to the multi-range frequency coverage in the 40-1450 MHz range, progressive mapping of the Milky Way with GMRT leads to a new visionary into HII regions, planetary nebulae, supernova remnants, voids, spurs, etc.

Different types of radio emissions have been discovered from many different types of stars in the last two decades. Among those, the red dwarf flare stars of UV Cetitype are the most prominent ones at the meter wavelengths.

- **The Upgraded GMRT**

All of the above studies were based on observations with the original GMRT, with a maximum bandwidth of ≈ 32 MHz, and with narrow frequency bands, covering ≈ 150 − 156 MHz, ≈ 230−245 MHz, ≈ 300−360 MHz, ≈ 570−660 MHz, and ≈ 900 − 1450 MHz The GMRT is currently being upgraded, with the installation of new receivers covering ≈ 125 − 250 MHz, ≈ 250−500 MHz, ≈ 550−850 MHz, and ≈ 950−1450 MHz and a new wideband correlator with a bandwidth of 400 MHz. This will increase the telescope sensitivity for progressive and pulsar studies in the U-V coverage of the array for progressive studies of complex sources, and in the frequency coverage for studies ofredshifted HI, OH emission, and absorption and radio recombination lines.

- **The Expanded GMRT**

It is assumed that the frequency coverage of the GMRT will remain approximately unchanged in the expansion. This is because the mesh spacing of the current GMRT antennas would imply a rapid drop in sensitivity at frequencies. Initially,

considering the basic issue of the point-source sensitivity of the present GMRT and comparing this with the sensitivities of current and planned arrays, the three possible avenues for the expansion of the GMRT, to achieve

(1) A wider field of view,

(2) Improved surface brightness sensitivity

(3) Improved angular resolution, and hence a better confusion limit.

➢ Systems in GMRT

• GMRT Front-end System

Giant Meter-wave Radio Telescope (GMRT) Front Ends have been designed to operate at 5 frequency bands centered at 50 MHz, 150 MHz, 235 MHz, 327 MHz, 610 MHz and L-Band extending from 1000 to 1450 MHz. The L-Band is split into foursub-bands centered at 1060 MHz, 1170 MHz, 1280 MHz and 1390 MHz, each with a bandwidth of 120 MHz. The 150 MHz, 235 MHz and 327 MHz bands have about 40 MHz bandwidth and the 610 MHz band has about 60 MHz bandwidth. The low noise front end of the receiving system of GMRT has beendesigned to receive dual polarization. Lower frequency bands from 150 to 610 MHz have dual circular polarization channels (Right Hand Circular and Left-Hand Circular polarization) which have been conveniently named as CH1 and CH2, respectively. The higher frequency L-Band has dual linear polarization channels (Vertical and Horizontal polarization) and they have been named CH1 and CH2 respectively. The front-endsystem has flexibility to be configured for either dual polarization observation at a single frequency band or single polarization observation at two different frequency bands. The polarization channels can be swapped whenever required. For observing strong radio sources like "sun", the selectable solar attenuators of 14 dB, 33 dB can be used. The front end has RF termination facility also. Any band of the receiver can be switched OFF, whenever not in use, with the RF on/off facility provided in the front end. The receiver can be calibrated by injecting one of the four levels of calibrated noise, named Low calibration, Medium calibration, High calibration and Extra-highcalibration depending upon the flux density of the source being observed. To minimize cross coupling between channels, a phase switching facility using Walsh functions has beenprovided in the post unit.

• Feed Positioning System

Feed Positioning System as the name suggests is used to precisely position or focus the feeds that are located on the four faces of the rotating turret. The Telescope is to be operated at 150,233,327,610 and 1420 MHz. The feed can be positioned for desired frequency by rotating the feed turret. The precise positioning is achieved by using pulse width modulation technique to vary the speed of the DC motor as per the profile shown in fig. This is implemented with 8051 based microcontroller and feed drive cassette with power MOSFETSin 'H' configuration.

• Receiver System

A simplified block diagram of the GMRT receiver system is shown.

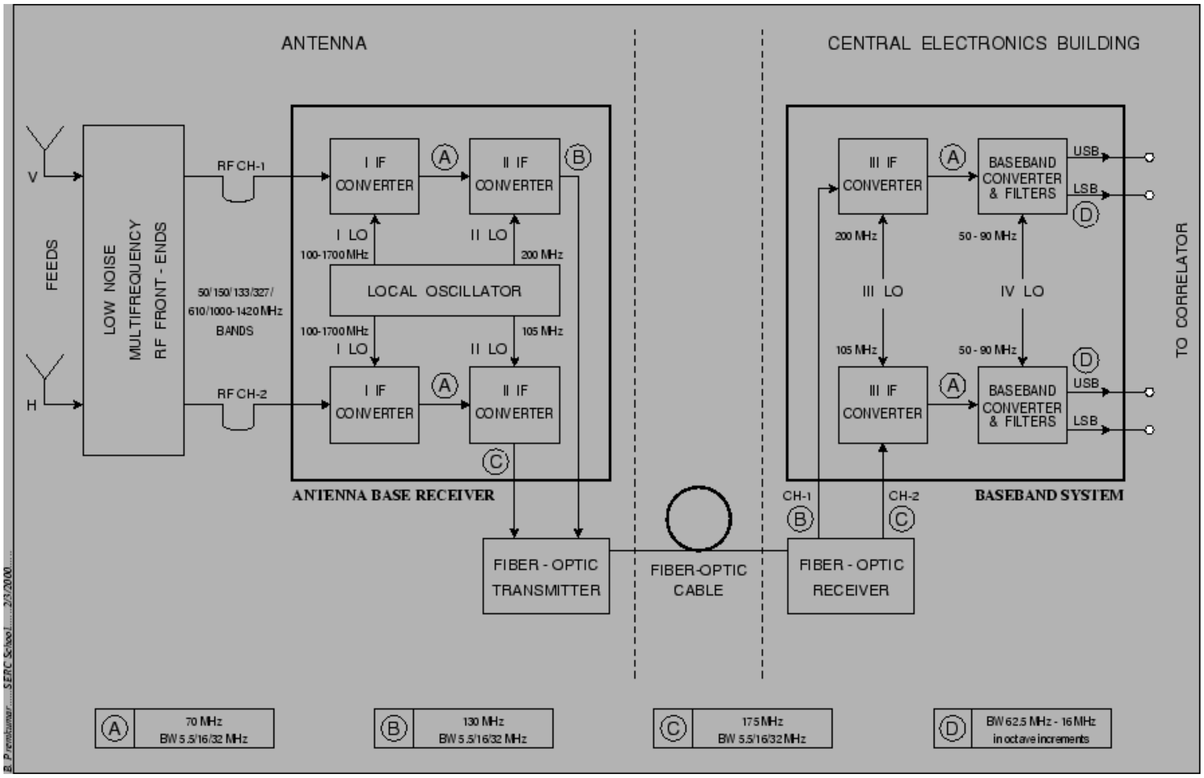


Fig 5: GMRT Receiver System

The antennas have dual polarised feeds at all the six frequencies.The feeds are mounted on the four faces of a micro-processer controlled rotating turret near the prime focus. The receiversystem consists of RF, LO, IF electronics and is required to have a very low system temperature and good phase stability. The linearly polarised signals received from the sky are converted to circularly polarised signals, amplified and brought through two low-loss cables to the base of the antenna. Then the RF signals are converted to 130 and 175 MHz band using the regenerated LO signals locked to a central frequency standard and transmitted to the CEB through the Single mode 1310 nm Optical Fiber cable and converted to the video signal of 16 MHz bandwidth by the baseband system. The back end consists of a correlator system which digitizes the analog signals at 32 MHz clock rate, introduces proper path delays to compensate for the time difference in the signal path to maximize the received signal from all the 30 antennas and helps in producing high quality image maps.

• Control and Monitoring System

The Control and Monitor System of a Radio Telescope is required to provide the necessary co-ordination between the various building blocks of the receiver system. This system is used for Controlling the activities of the various building blocks of GMRT like FE, LO, IF, BB, SERVO and FPS etc. and monitor the healthiness of the same in each of the antenna shells and CEB. It provides the human interface to persons like Telescope Observers, Scientists and maintenance personnel for operating all the antennas from CEB. It has to monitor all parts of the telescope system for correct operation and alert the operator in case of any anomalous behavior. And in the case of severe fault conditions, safety procedures have to be initiated locally. Ithas also to prevent human error from placing the telescope in a dangerous situation. This Control and Monitor System for GMRT tries to meet all the points mentioned above.

Objective

The project report aims to develop RHCP and LHCP helical antennas for precise polarization calibration within the GMRT system. Through meticulous design, simulation, fabrication, and testing, the antennas will be tailored to meet the specific requirements of GMRT's polarization calibration needs. The report will comprehensively outline the design process, detailing the considerations taken into account to optimize antenna performance. Simulation results will be presented to demonstrate the expected behavior of the antennas under various conditions. Fabrication techniques utilized will be elucidated, showcasing the steps taken to translate theoretical designs into physical prototypes. Experimental testing procedures will be meticulously described, highlighting the methodologies employed to assess the antennas' performance in real-world GMRT environments. Ultimately, the report seeks to validate the efficacy of the RHCP and LHCP helical antennas in achieving accurate polarization calibration within the GMRT system, providing valuable insights into their functionality and potential applications in radio astronomy.

THEORY

An Antenna is basically a transducer. It converts radio frequency RF signal into an electromagnetic wave of same frequency.

Helical antennas are distinctive for their coiled wire structure around a central tube, affecting their radiation patterns and polarization, such as RHCP or LHCP, determined by the direction of the coil. These antennas operate in two primary modes: "normal" mode, where the coil dimensions are relatively smaller compared to the signal wavelength, resulting in omnidirectional radiation, and "axial" mode, where the coil dimensions are comparable to the signal wavelength, leading to directional radiation along the antenna axis. Axial mode helical antennas excel at emitting circularly polarized radio waves, making them prevalent in research fields requiring circular polarization across diverse frequency bands like VHF and UHF.

Despite their apparent simplicity, helical antennas exhibit remarkable effectiveness, particularly in axial mode, where they offer heightened directivity and wideband performance. However, normal mode operation is less favorable due to reduced efficiency and narrower beamwidth. This underscores the significance of mode selection based on specific research requirements, with axial mode helical antennas often preferred for their superior performance characteristics in directional communication and circular polarization studies.

The IEEE defines the sense of polarization as: "the sense of polarization, or handedness ... is called right-handed (left-handed) if the direction of rotation is clockwise (anti-clockwise) for an observer looking in the direction of propagation “

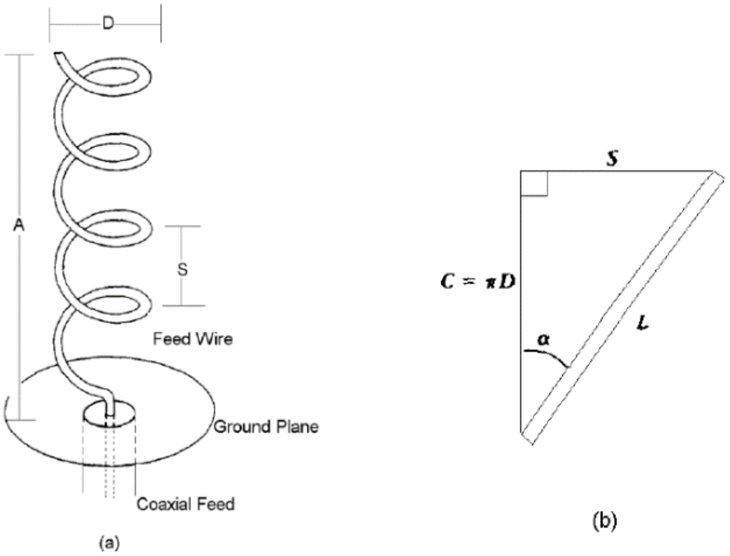
Thus, a right-handed helix radiates a wave which is right-handed, the electric field vector rotating clockwise looking in the direction of propagation

Proposed Methodology

In this Report I have designed a helical antenna capable of generating Right-Hand Circular Polarization (RHCP) and Left-Hand Circular Polarization (LHCP) efficiently. Further it was ensured that the helical antenna operates within the desired frequency band suitable for intended application. Then the aim was to test the polarization purity of giant meter wave radio telescope antennas, and finally a comprehensive analysis and simulations were achieved.

Geometry of Antenna

The parameters that describe the helix are summarized below as –
D: Diameter of helix
A: Axial length of helical antenna
d: diameter of helix conductor
C: Circumference of helix
N: Number of turns
α: pitch angle
Dg: Diameter of ground plane
S: Pitch (distance between two turns)



(a) Geometry of helical Antenna (b) Unrolled turn of helical Antenna.

Design Parameters

The Helical Antenna is designed for BAND-4 which includes frequency range as 550MHz-900MHz. I have designed total Eight helical antenna for all four u-gmrt bands that is band2, band3, band4, band5. Here I am showing band 4 RHCP and LHCP Helical antenna results. At last, I included the all-band results. Figure 1 is showing the front view geometry and the structure designed on Ansys HFSS software of proposed axial mode antenna at center frequency 725MHz. This is a RHCP Helical Antenna.

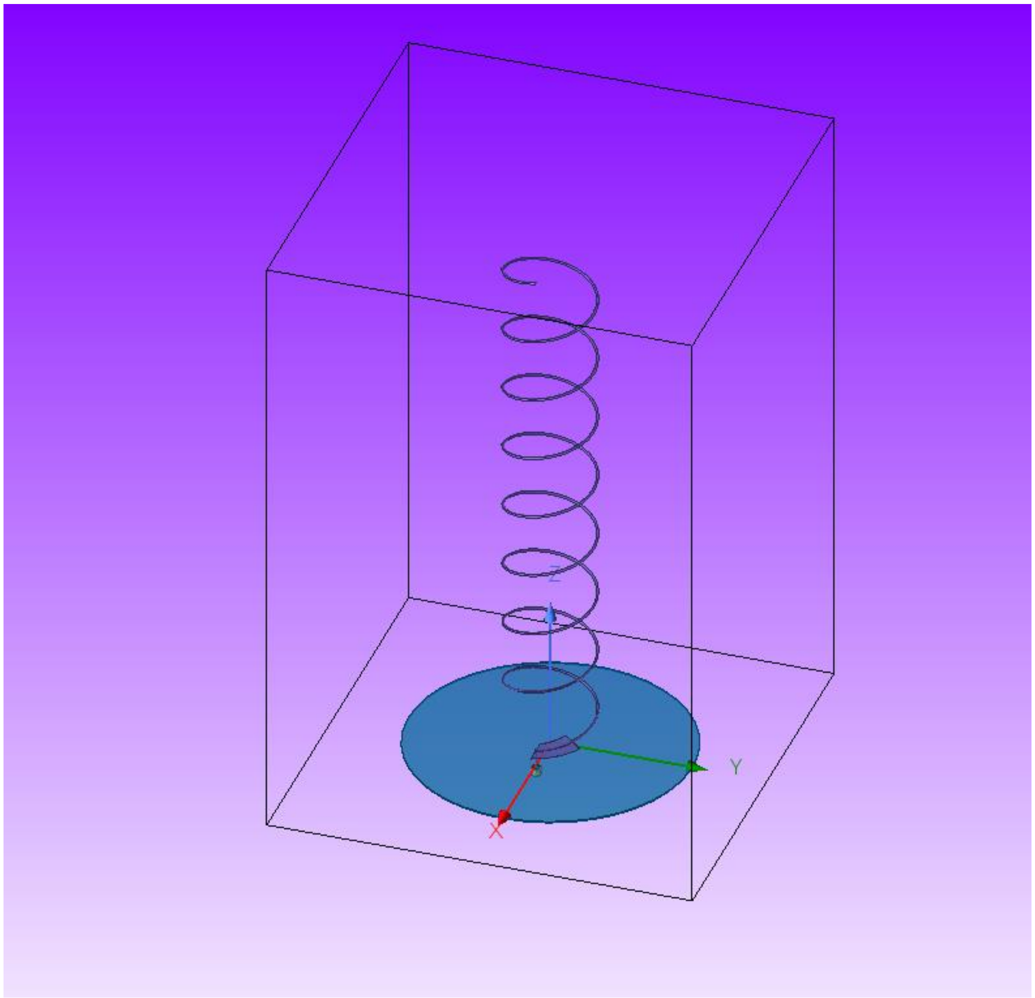
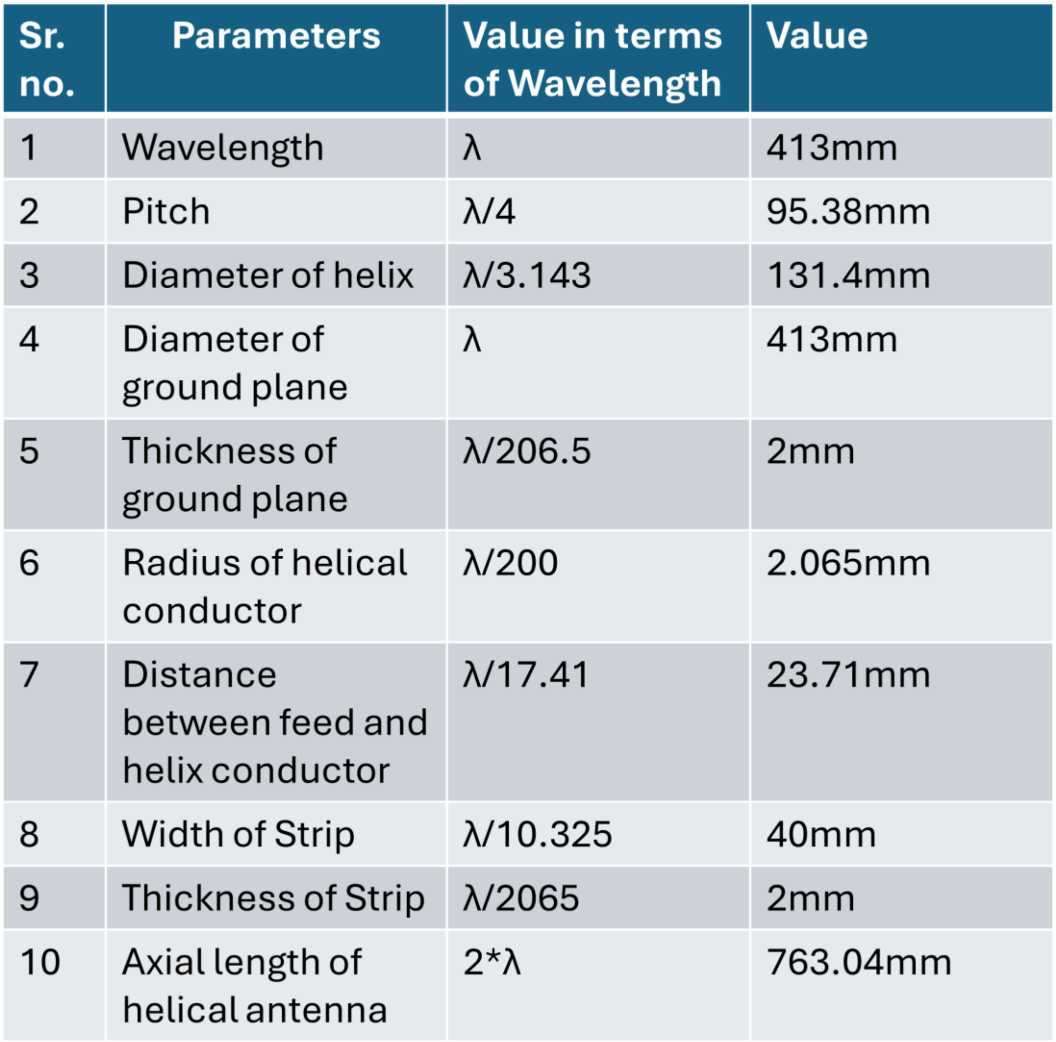


Fig:1

Table no. 1



Sr. no.	Parameters	Value in terms of Wavelength	Value
1	Wavelength	λ	413mm
2	Pitch	λ/4	95.38mm
3	Diameter of helix	λ/3.143	131.4mm
4	Diameter of ground plane	λ	413mm
5	Thickness of ground plane	λ/206.5	2mm
6	Radius of helical conductor	λ/200	2.065mm
7	Distance between feed and helix conductor	λ/17.41	23.71mm
8	Width of Strip	λ/10.325	40mm
9	Thickness of Strip	λ/2065	2mm
10	Axial length of helical antenna	2*λ	763.04mm

The axial ratio characterizes the polarization purity of the helix antenna.
It can also be termed as the measure of CP and defined as a ratio of magnitude of the orthogonal E-field components i.e., Ex/Ey.

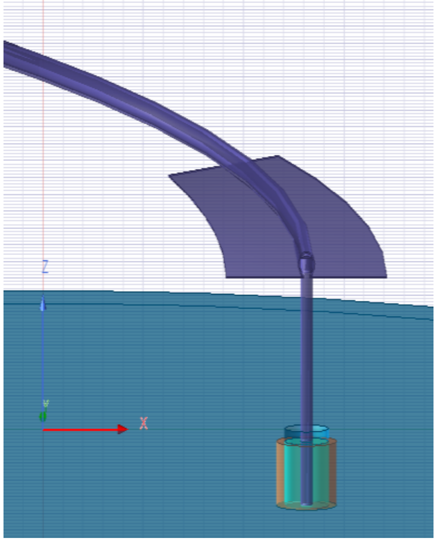
As the number of loops N increases, the axial ratio decreases.
Axial Ratio (AR) = $1 + 1/2N$

For N = 8, it is., AR = $1 + 1/\ (2*(8))$
$= 1 + 1/16 = 1.0625$
Since it is very close to one, so we will the circular polarization.

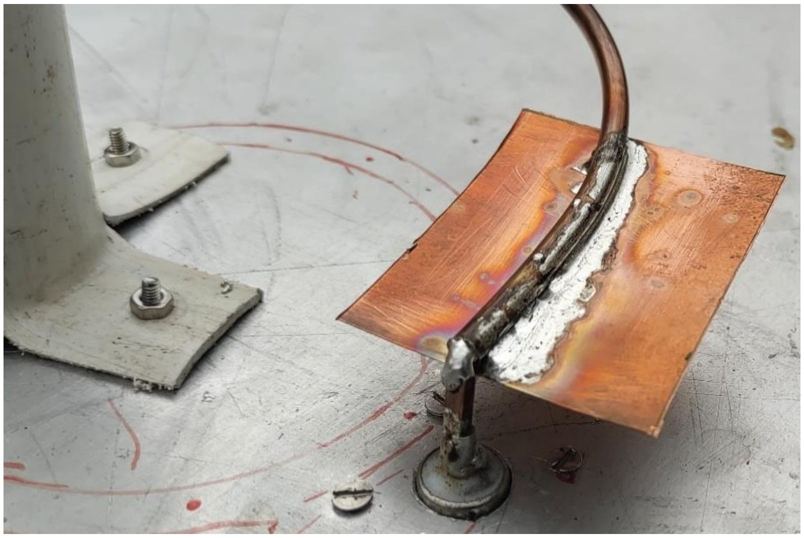
Axial Ratio vs Polarization type

Sr. no.	Axial Ratio Value	Polarization Type
1	0	Linear horizontal polarization
2	∞	Linear vertical polarization
3	1	Circular polarization
4	Between 0 and 1	Elliptical polarization

Impedance Matching Technique



Simulated



Real

Here I have used a Rectangular Conductive strip for the impedance Matching of the helical antenna. Here impedance matching is done by adding a Metal conductive strip to the first quarter turn, this increases the helix conductor's surface area and forms a "capacitor" with the reflector plate. And similarly, I have designed the matching strip for the other u-gmrt band helical antennas.

Fabricated Antennas

Fabricated BAND-4 RHCP Helical Antenna

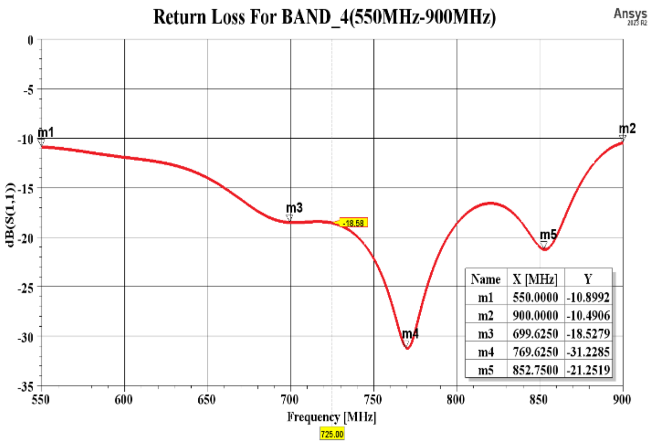
Fabricated BAND-4 LHCP Helical Antenna

Fabricated BAND-5 RHCP Antenna

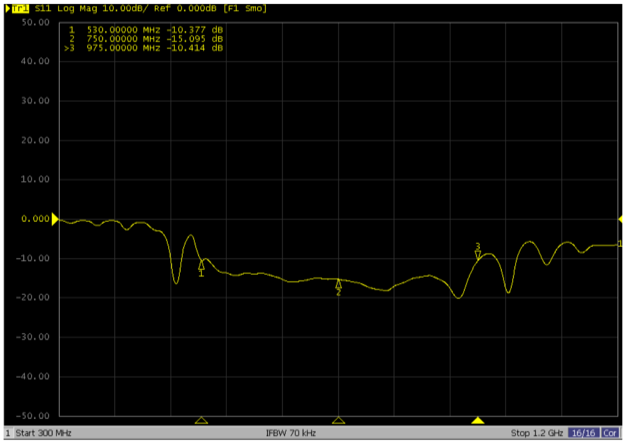
Matching Conductive strip

Results

RHCP

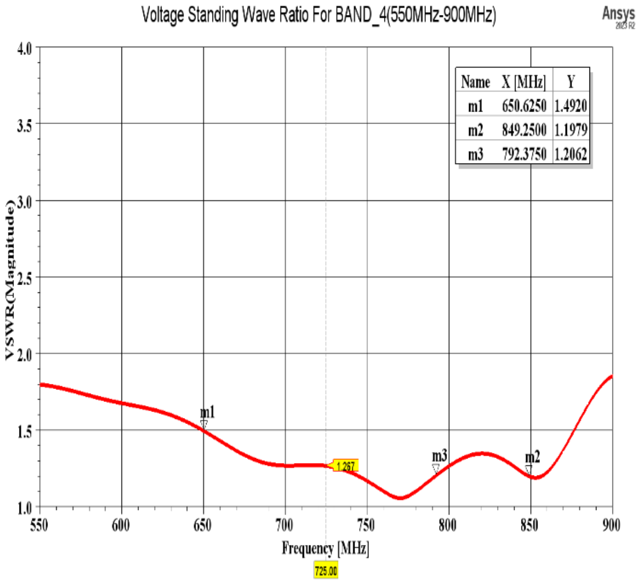


Name	X [MHz]	Y
m1	550.0000	-10.8992
m2	900.0000	-10.4906
m3	699.6250	-18.5279
m4	769.6250	-31.2285
m5	852.7500	-21.2519

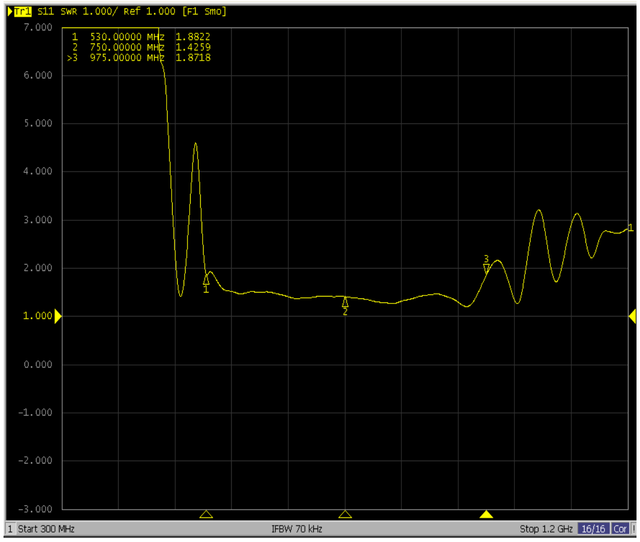

```
Tr1 S11 Log Mag 10.00dB/ Ref 0.000dB [F1 Smo]
 1   530.00000 MHz -10.377 dB
 2   750.00000 MHz -15.095 dB
>3   975.00000 MHz -10.414 dB
1 Start 300 MHz          IFBW 70 kHz          Stop 1.2 GHz 16/16 Cor
```

Simulated **Measured**

Above Figures depicts the Simulated and Measured (On network Analyzer) Return loss for Band4 RHCP which is 550MHz – 900MHz. for the whole bandwidth the return loss is less than -10 dB. Thus, covering the whole bandwidth and at the center frequency 725MHz the value of return loss is -18.58dB.

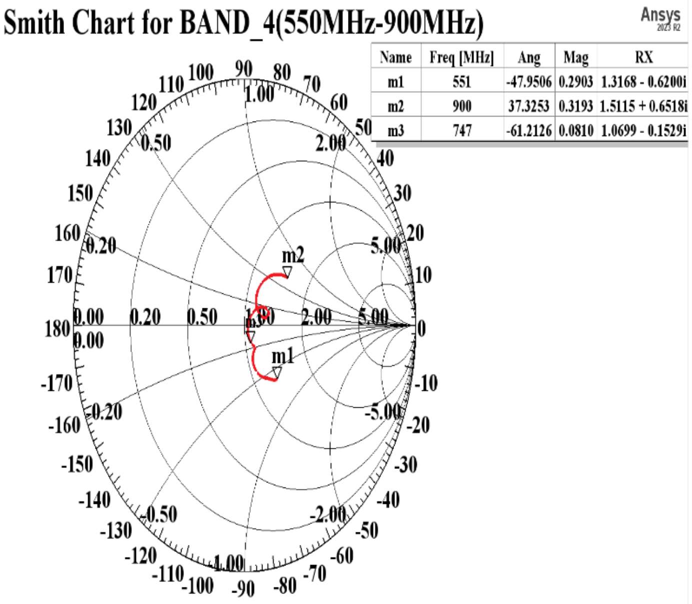


Name	X [MHz]	Y
m1	650.6250	1.4920
m2	849.2500	1.1979
m3	792.3750	1.2062


```
Tr1 S11 SWR 1.000/ Ref 1.000 [F1 Smo]
 1   530.00000 MHz  1.8822
 2   750.00000 MHz  1.4259
>3   975.00000 MHz  1.8718
1 Start 300 MHz          IFBW 70 kHz          Stop 1.2 GHz 16/16 Cor
```

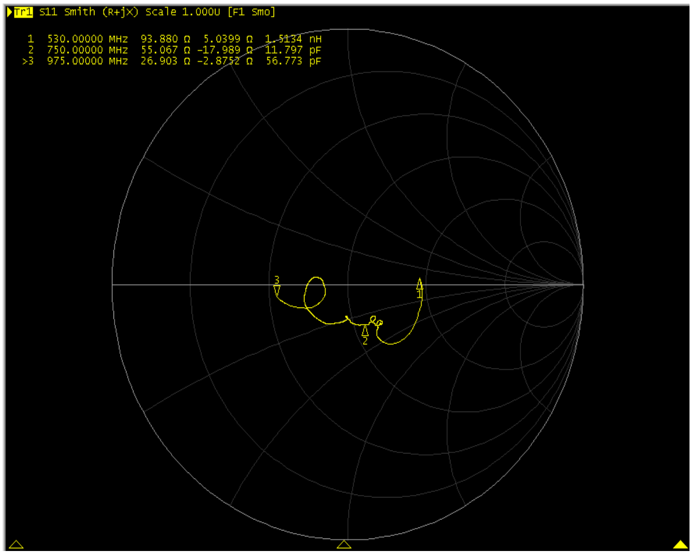
Simulated **Measured**

Above curve shows the Voltage Standing wave ratio parameter for band4 RHCP helical antenna. It is obvious that its magnitude is less than 2 for whole bandwidth. Thus, we can say that very less chance of formation of standing waves.



Name	Freq [MHz]	Ang	Mag	RX
m1	551	-47.9506	0.2903	1.3168 - 0.6200i
m2	900	37.3253	0.3193	1.5115 + 0.6518i
m3	747	-61.2126	0.0810	1.0699 - 0.1529i

Simulated

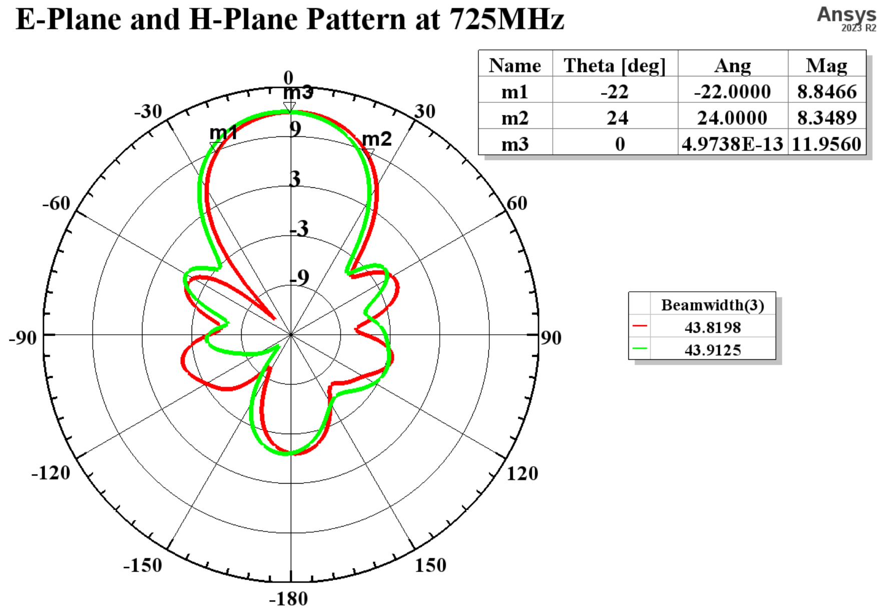


```
Tr1 S11 Smith (R+jX) Scale 1.000U [F1 Smo]

  1  530.00000 MHz  93.880 Ω  5.0399 Ω  1.5134 nH
  2  750.00000 MHz  55.067 Ω -17.989 Ω  11.797 pF
 >3  975.00000 MHz  26.903 Ω -2.8752 Ω  56.773 pF
```

Measured

Above curve shows the impedance characteristics for Band 4 RHCP Helical antenna. It is obvious that it circles inside the 50ohm circle that means we have achieved almost perfect matching.



Name	Theta [deg]	Ang	Mag
m1	-22	-22.0000	8.8466
m2	24	24.0000	8.3489
m3	0	4.9738E-13	11.9560

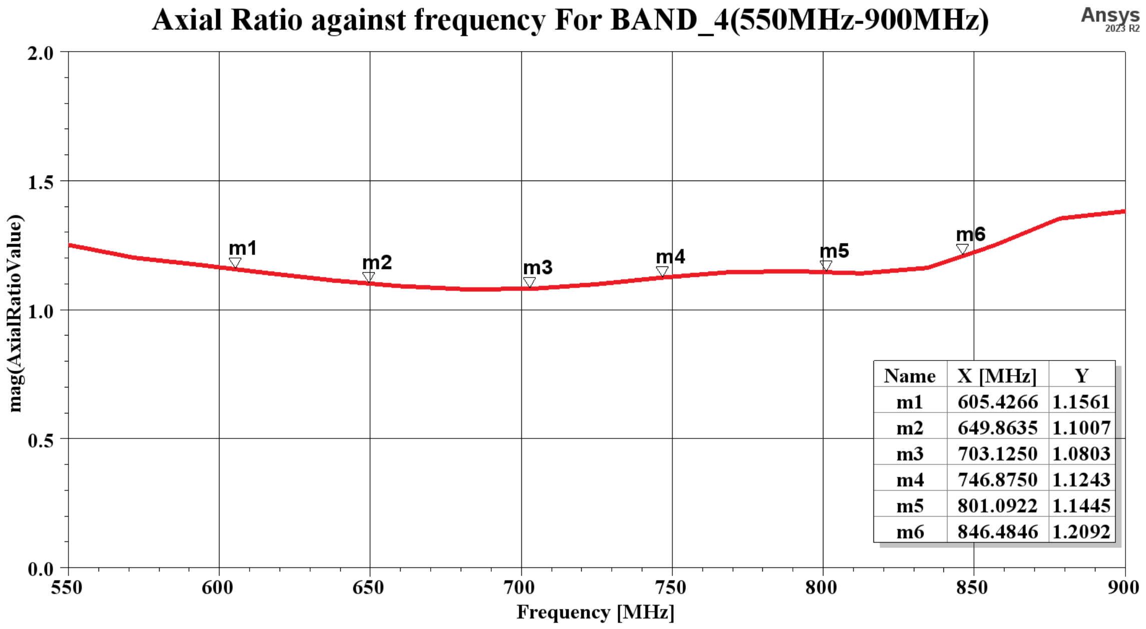
Half power Beamwidth is the angular separation in which the magnitude of radiation pattern is -3dB from the peak of main beam.

Red curve shows E-Plane Pattern
Green curve shows H-Plane Pattern

E-Plane Pattern
HPBW: 43.8198

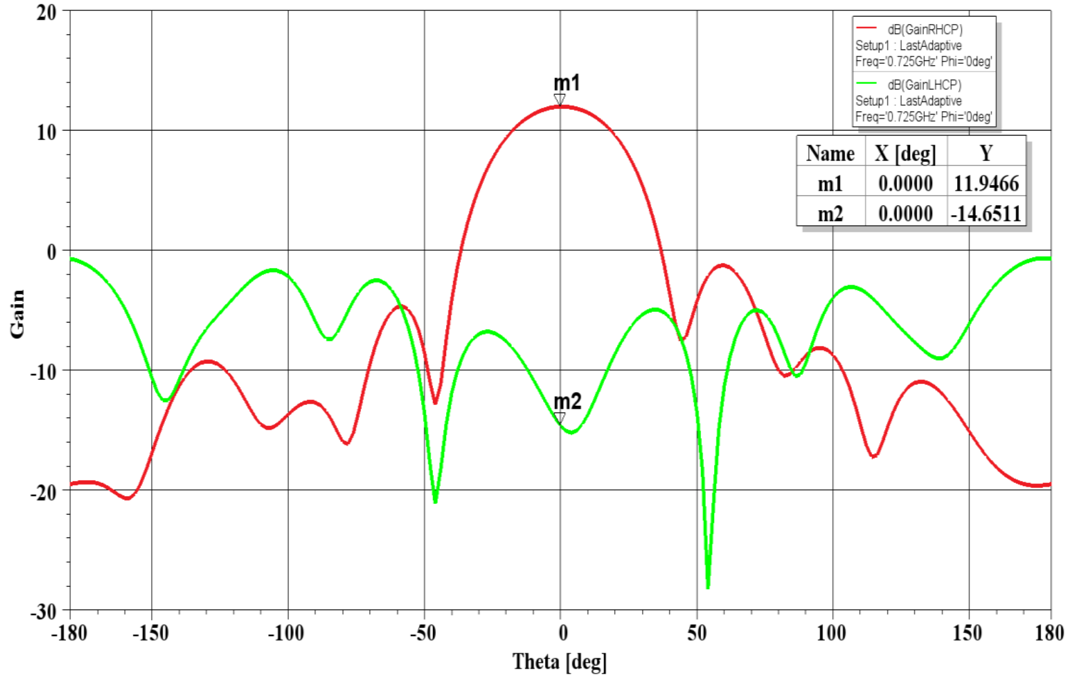
H-Plane Pattern
HPBW: 43.9125

Above figure shows the E-plane and H-plane Radiation Pattern for the Band4 RHCP helical antenna, since both the planes are almost overlapping that means we are getting circular polarization and as you see the gain we are achieving is 11.9dB.



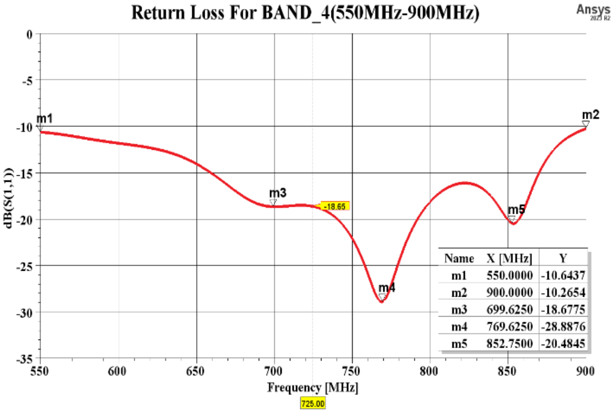
The axial ratio characterizes the polarization purity of the helical antenna. Here in above curve, we can see it is near to 1 that means for whole bandwidth we get circular polarization effectively.

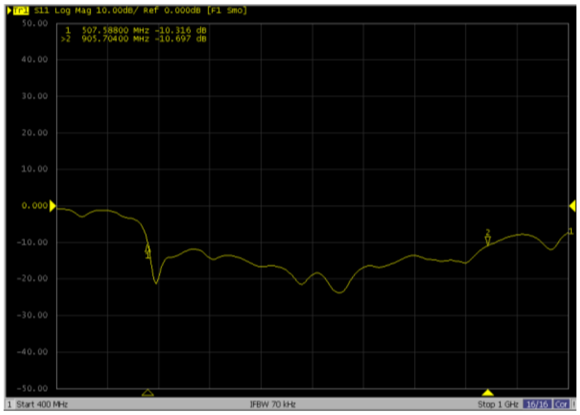
RHCP ANTENNA GAIN IN RHCP AND LHCP MODES



Above Curve shows the gain of RHCP Helical Antenna in RHCP mode and in LHCP mode, thus we can see and inference that two signal have large gap between that is of 25 dB, preventing interference of signal. So, the intended signal is receiving properly.

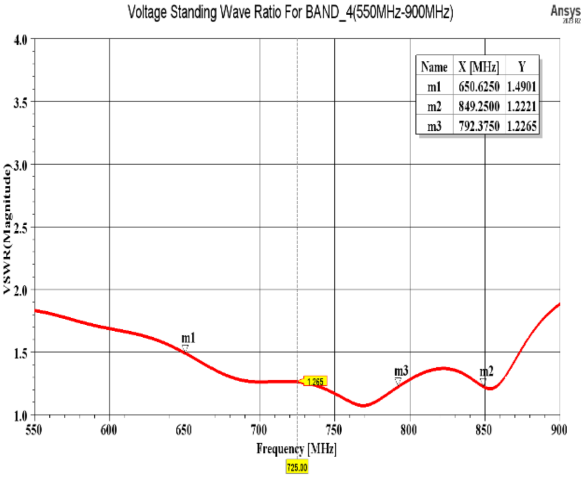
LHCP

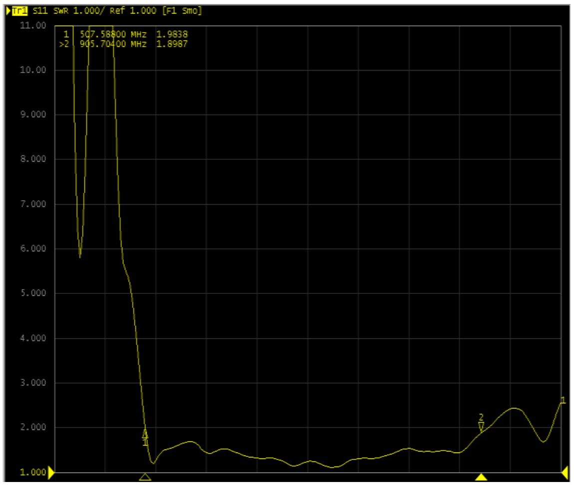




Simulated **Measured**

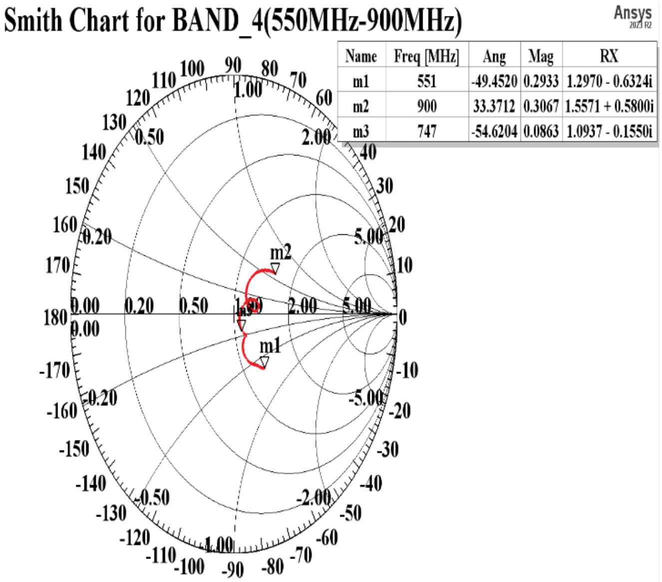
Above Figures depicts the Simulated and Measured (On network Analyzer) Return loss for Band4 LHCP which is 550MHz – 900MHz. for the whole bandwidth the return loss is less than -10 dB. Thus, covering the whole bandwidth and at the center frequency 725MHz the value of return loss is -18.88dB.





Simulated **Measured**

Above curve shows the Voltage Standing wave ratio parameter for band4 LHCP helical antenna. It is obvious that its magnitude is less than 2 for whole bandwidth. Thus, we can say that very less chance of formation of standing waves.



Smith Chart for BAND_4(550MHz-900MHz)

Name	Freq [MHz]	Ang	Mag	RX
m1	551	-49.4520	0.2933	1.2970 - 0.6324i
m2	900	33.3712	0.3067	1.5571 + 0.5800i
m3	747	-54.6204	0.0863	1.0937 - 0.1550i

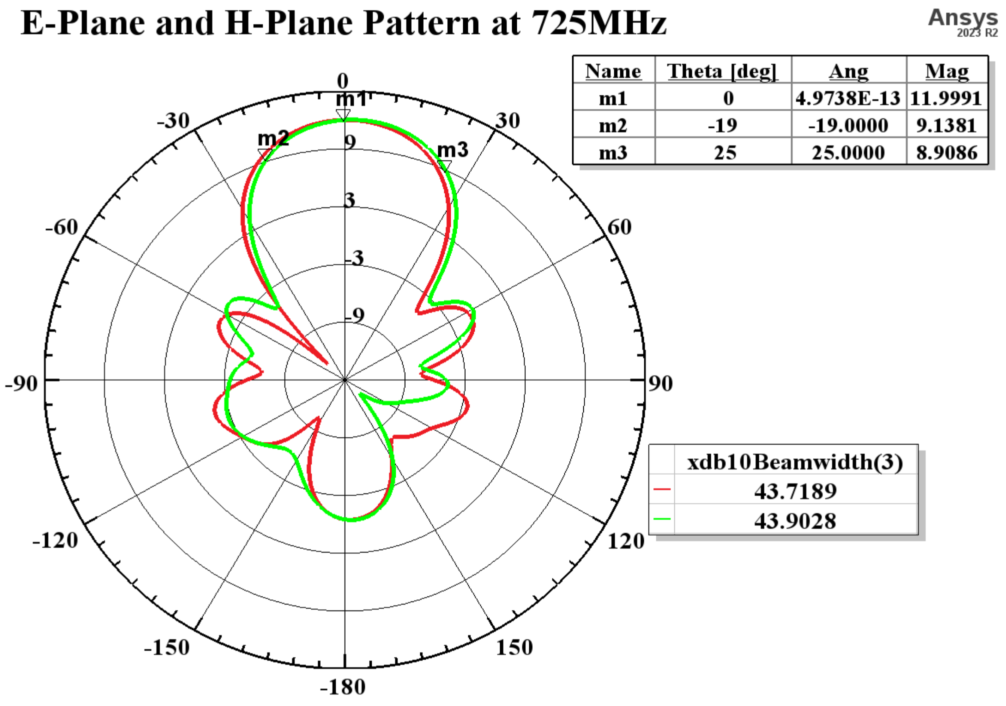
Simulated

```
Tr1 S11 Smith (R+jX) Scale 1.000U [F1 Smo]

 1  507.58800 MHz  26.123 Ω -1.0981 Ω  285.54 pF
>2  905.70400 MHz  77.311 Ω  29.059 Ω  5.1065 nH
```

Measured

Above curve shows the impedance characteristics for Band 4 LHCP Helical antenna. It is obvious that it circles inside the 50ohm circle that means we have achieved almost perfect matching.

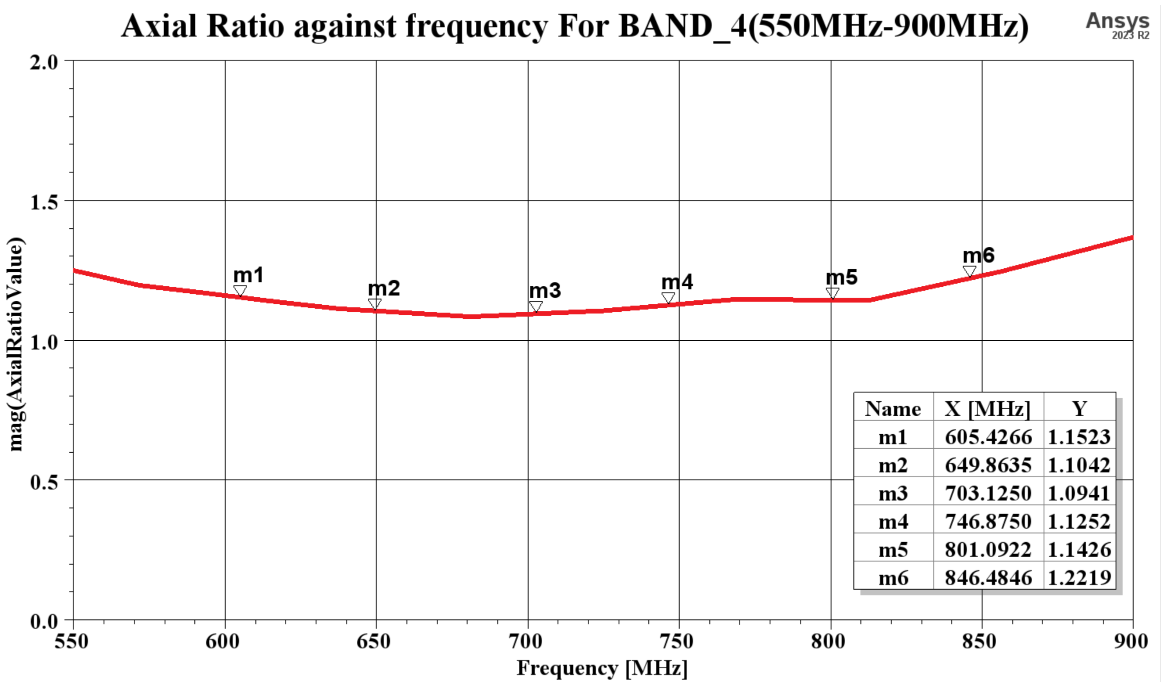


Red curve shows E-Plane Pattern
Green curve shows H-Plane Pattern

E-Plane Pattern
HPBW: 43.7189

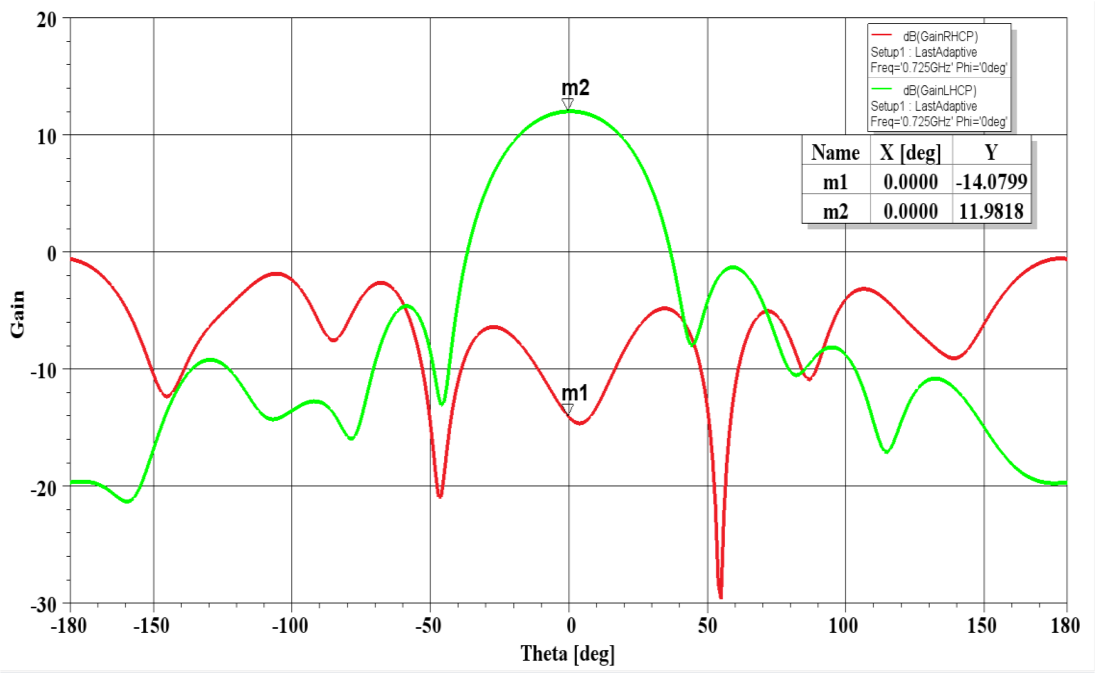
H-Plane Pattern
HPBW: 43.9028

Above figure 4 shows the E-plane and H-plane Radiation Pattern for the Band4 LHCP helical antenna, since both the planes are almost overlapping that means we are getting circular polarization and as you see the gain we are achieving is 11.9dB.



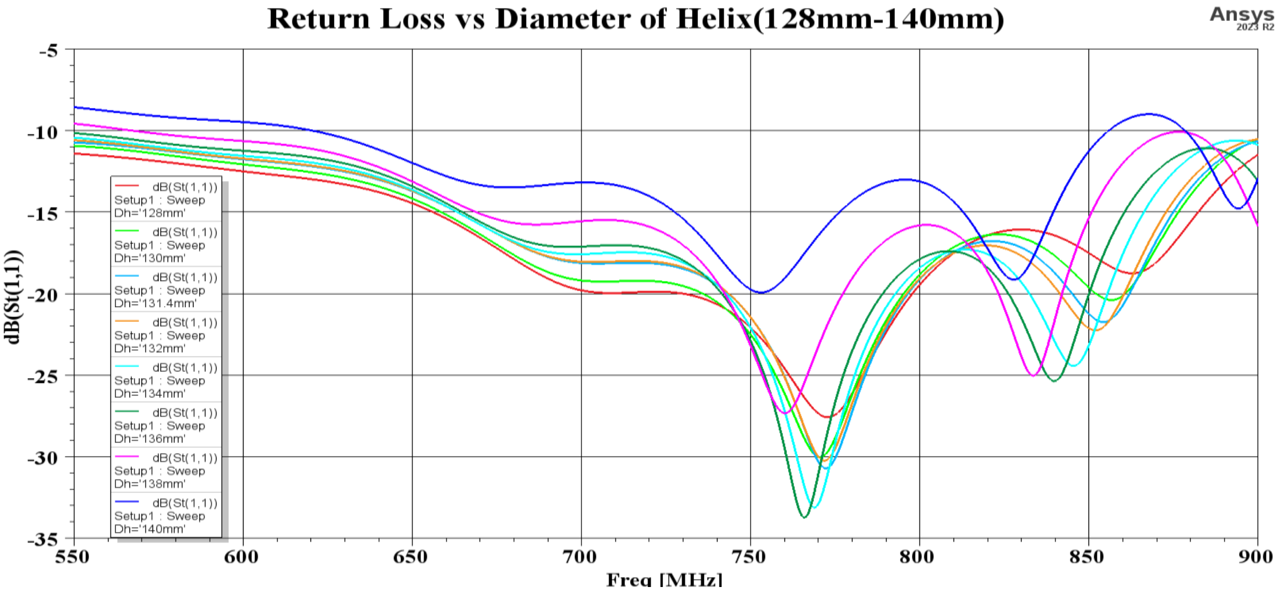
The axial ratio characterizes the polarization purity of the helical antenna. Here in above curve, we can see it is near to 1 that means for whole bandwidth we get circular polarization effectively.

LHCP ANTENNA GAIN IN RHCP AND LHCP MODES

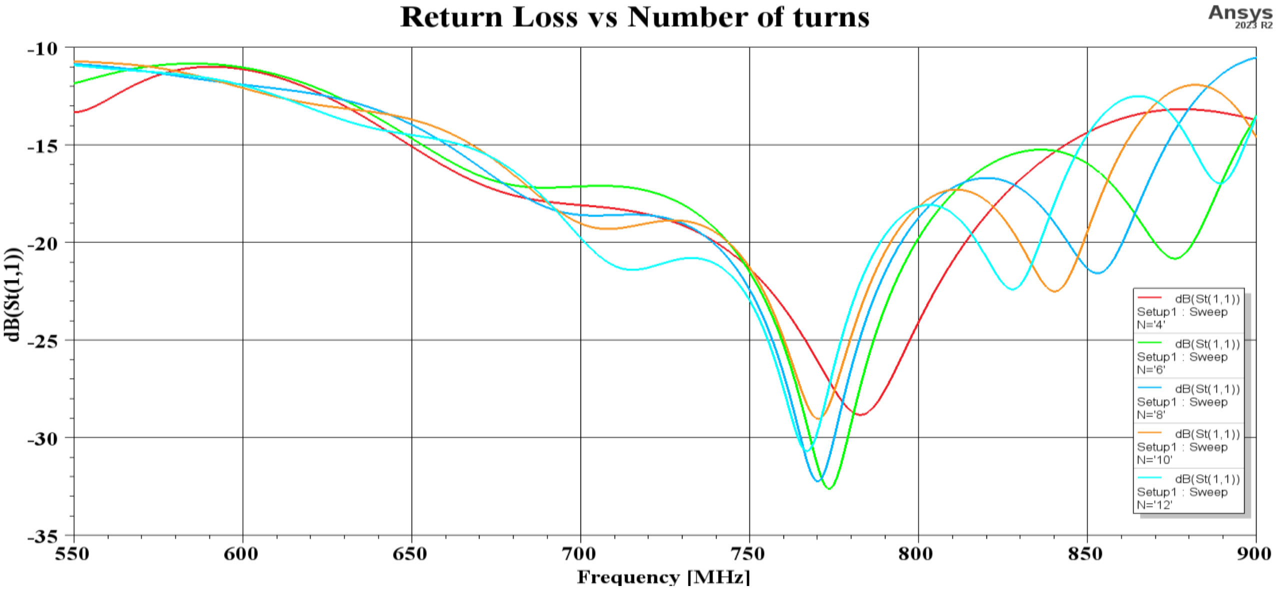


Above Curve shows the gain of LHCP Helical Antenna in RHCP mode and in LHCP mode, thus we can see and inference that two signal have large gap between that is of 25 dB, preventing interference of signal. So, the intended signal is receiving properly.

Return Loss(S11) vs Varying values of helix parameters

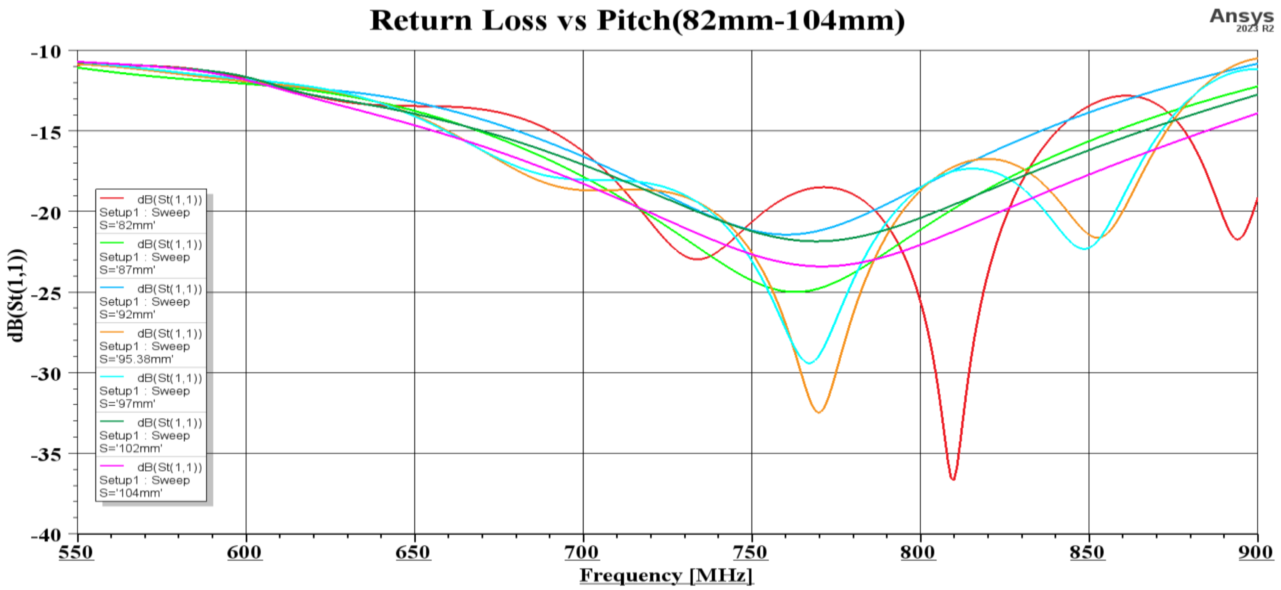


Above graph shows change in S11 when there is change in diameter of helix. In this curve helix diameter is varied from 128mm to 140mm and S11 is recorded.
It is seen that at Dh = 131.4mm we get most optimum result.



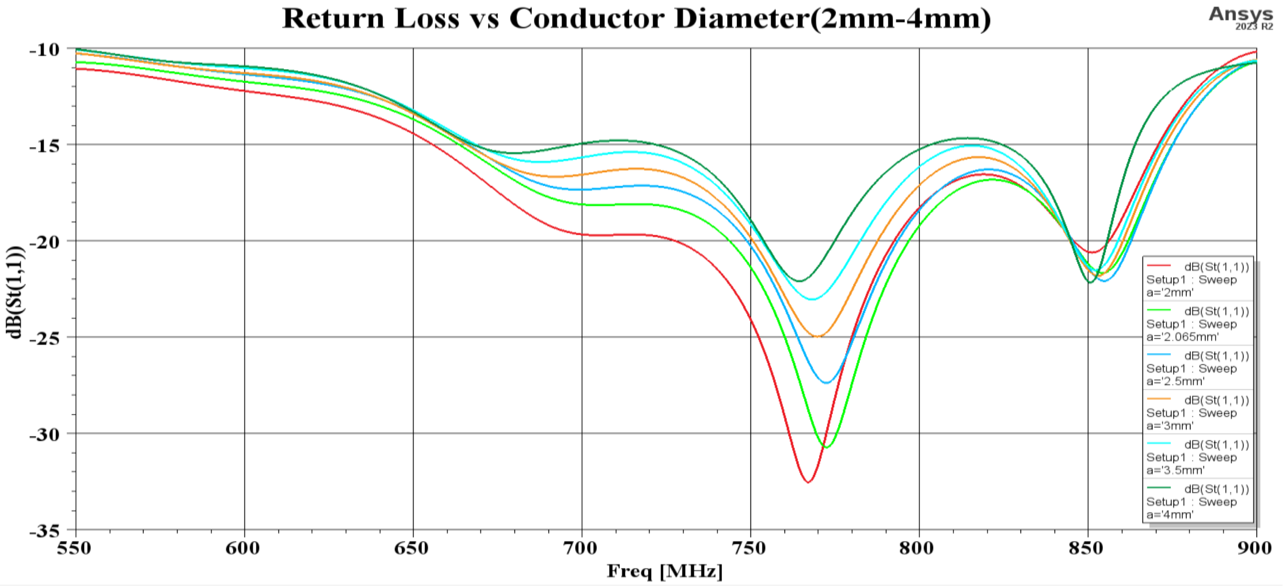
Above graph shows change in S11 when there is change in Number of turns of helix. In this curve number of turns is varied from 4 to 12 and S11 is recorded.

It is seen that at N = 8 we get most optimum result.



Above graph shows change in S11 when there is change in Pitch (Spacing between helical turns) of helix. In this curve helix diameter is varied from 82mm to 104mm and S11 is recorded.

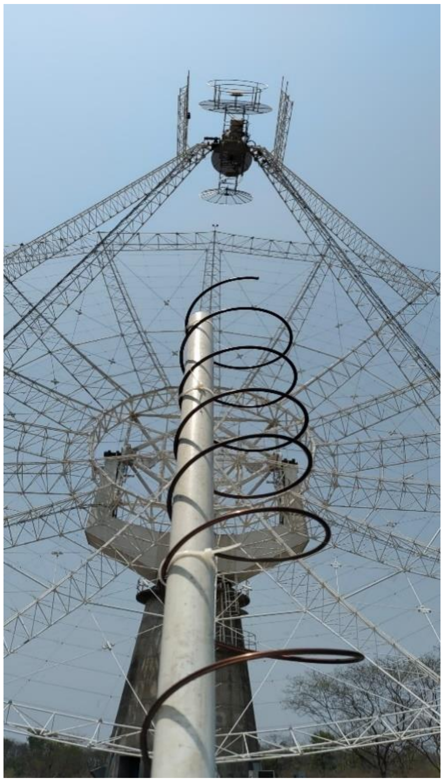
It is seen that at S = 95.38mm, we get most optimum result.



Above graph shows change in S11 when there is change in diameter of helical conductor. In this curve helical conductor is varied from 2mm to 4mm and S11 is recorded.

It is seen that at 2R = 4mm, we get most optimum result.

Polarization Isolation measurement test at C10 Antenna GMRT



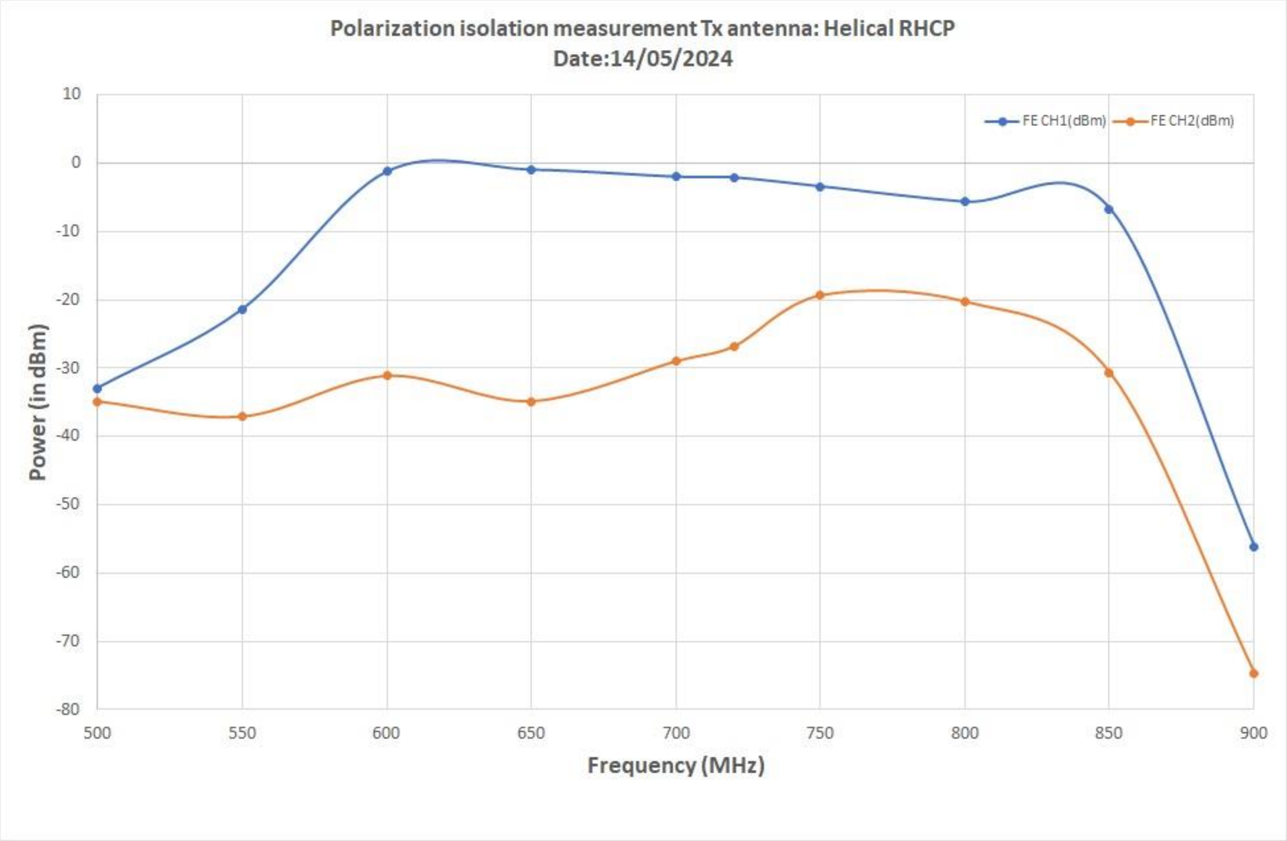
Above pictures shows the team and the helical antenna setup for the polarization isolation test at C10 GMRT antenna. Here we have aligned the helical antenna with the giant antennas feed system to configure Band-4 Reception. After this, line of sight arrangement, we used a signal generator in order to radiate circularly polarized wave from helical antenna.
At the Antenna base we have used a spectrum Analyzer to analyze the receiving signal we were receiving in channel 1 and channel 2.

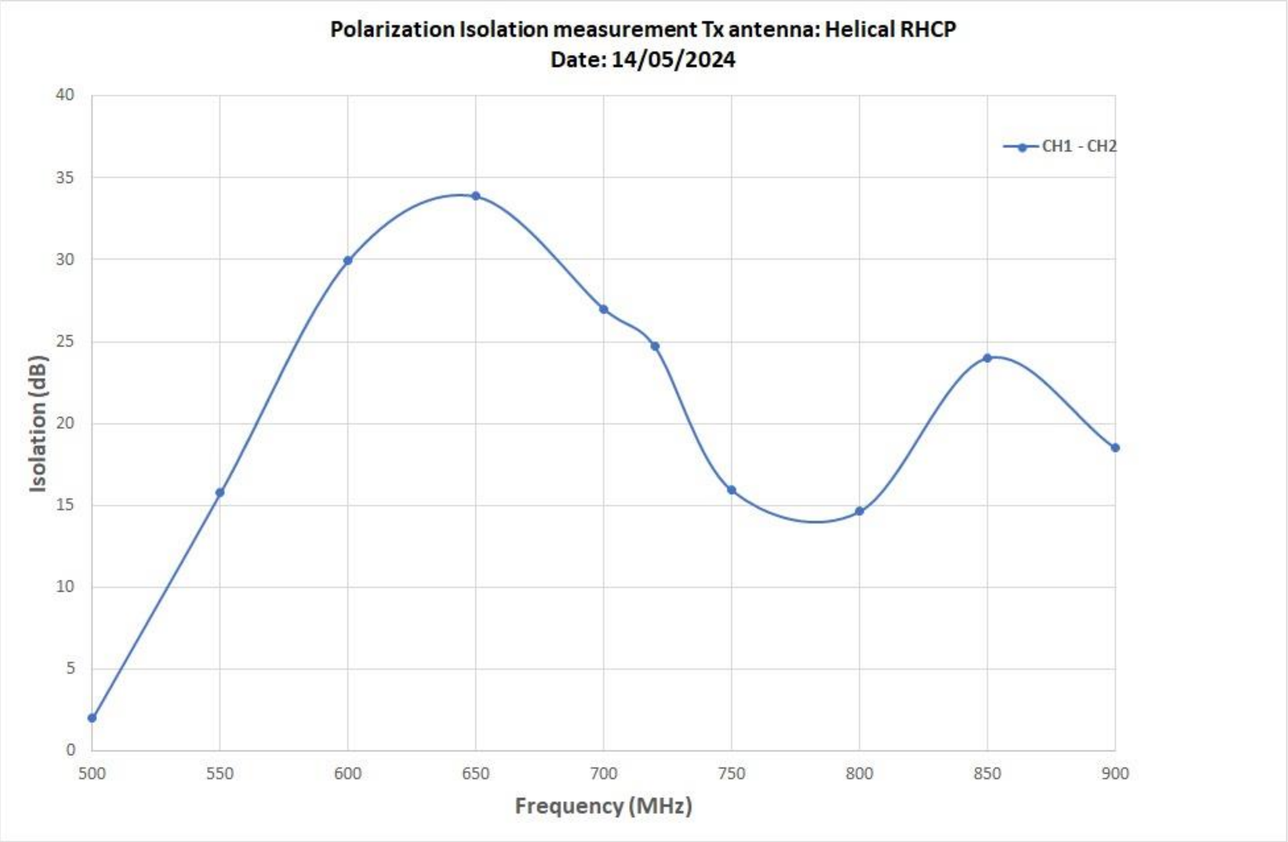
For LHCP transmitter signal the received power in channel 2 is higher than in channel 1. The difference between power levels shows the isolation between the two polarizations of GMRT Antenna.

Similarly, we tested with the RHCP helical antenna and signal received in channel 1 was higher as compared to channel 2. So here also we got optimum isolation between the two polarizations of GMRT Antenna.

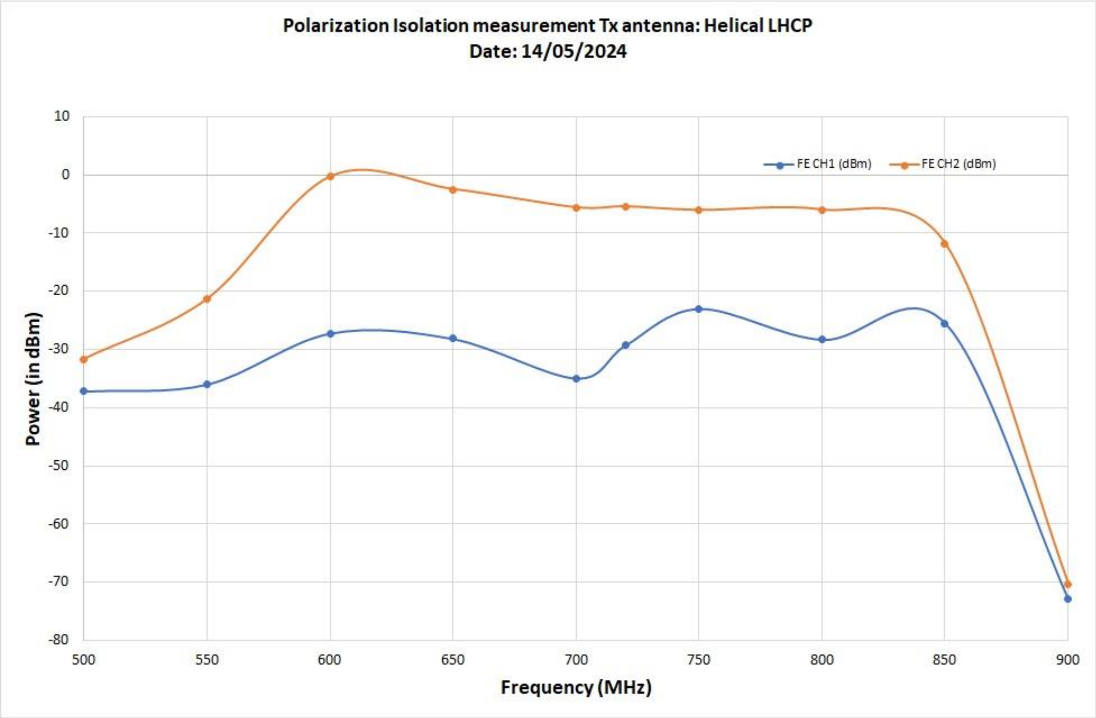
Similar measurement was conducted with RHCP Geostationary Satellite Signals in BAND 5 i.e., L BAND. The Results were consistent in both cases as per the GMRT convention.

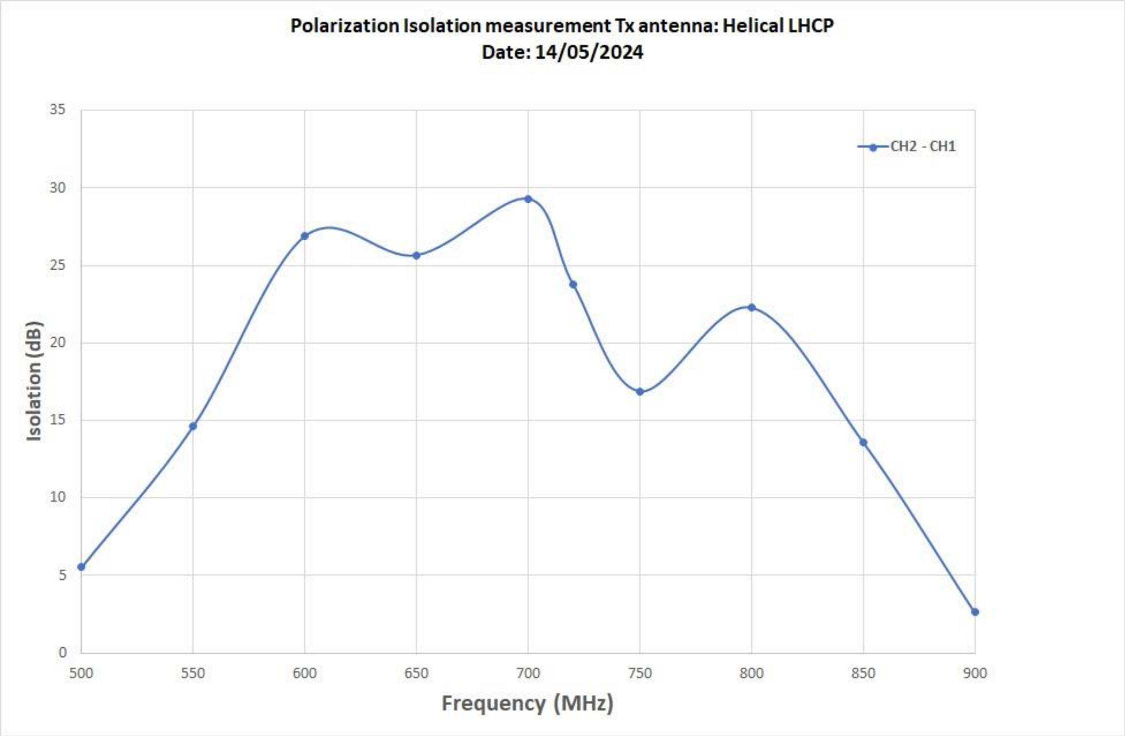
Results





This Curve shows Isolation(CH1 - CH2) between the two channels, when the transmitting signal was RHCP.



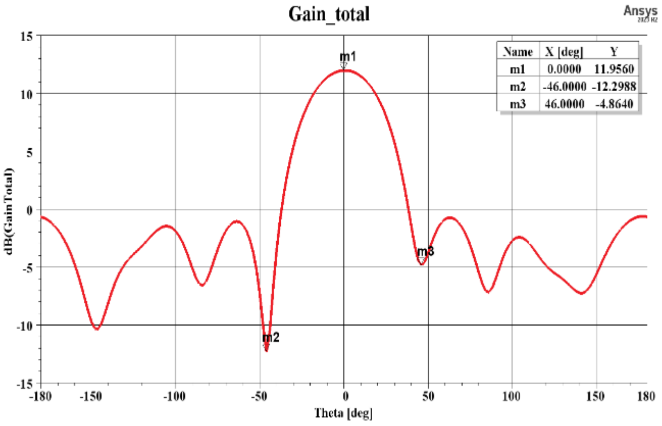


This Curve shows Isolation (CH2 – CH1) between the two channels, when the transmitting signal was LHCP.

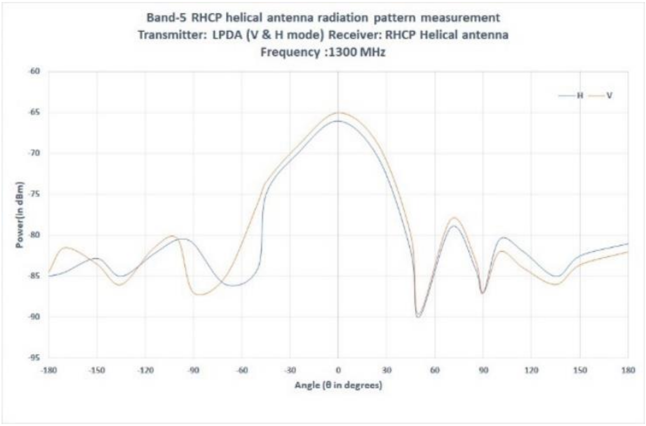
Experimental Setup for The Radiation Pattern for Band-4 RHCP Helical Antenna

This test was done to Characterize the Beamwidth and Gain of Designed Band 5 RHCP Helical Antenna. We have used LPDA – Log periodic Dipole Array as Transmitting Antenna in V & H Mode and for Receiving side we used our Designed BAND 5 RHCP helical Antenna (AUT).

Results:



Simulated



Measured

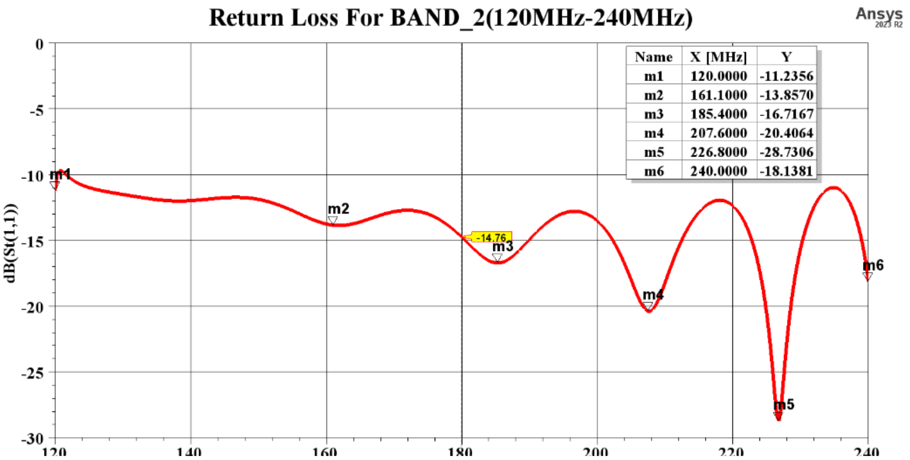
According to Friss Formula,
Free space path loss = - 54.72dB
So,

Gain can be given as: -30dBm + Tx gain -FSL + Rx gain = -66dBm
-30 + 6.4 -54.72 + Rx gain = -66
Rx gain = 12.32dB

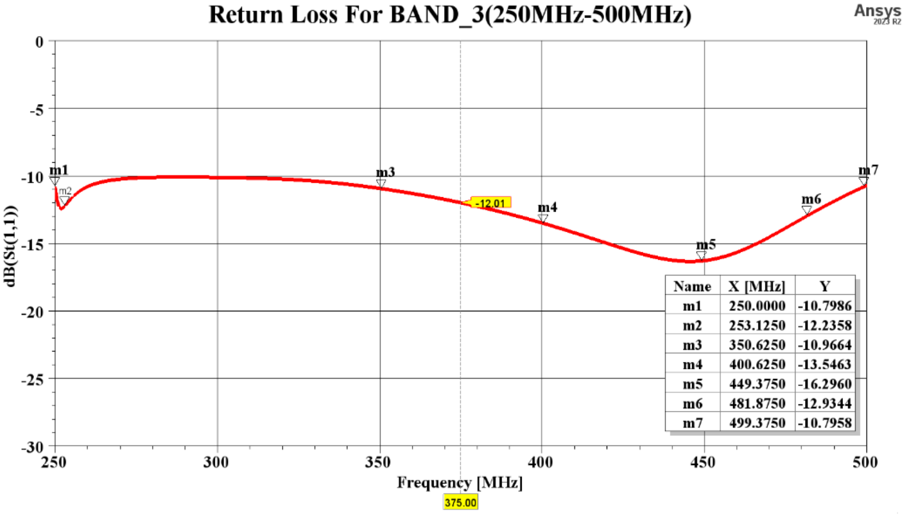
So, the Experimental Gain is Almost Equal to the Simulated gain we achieved in Ansys hfss software.

Other bands of u-GMRT Results are as follow:

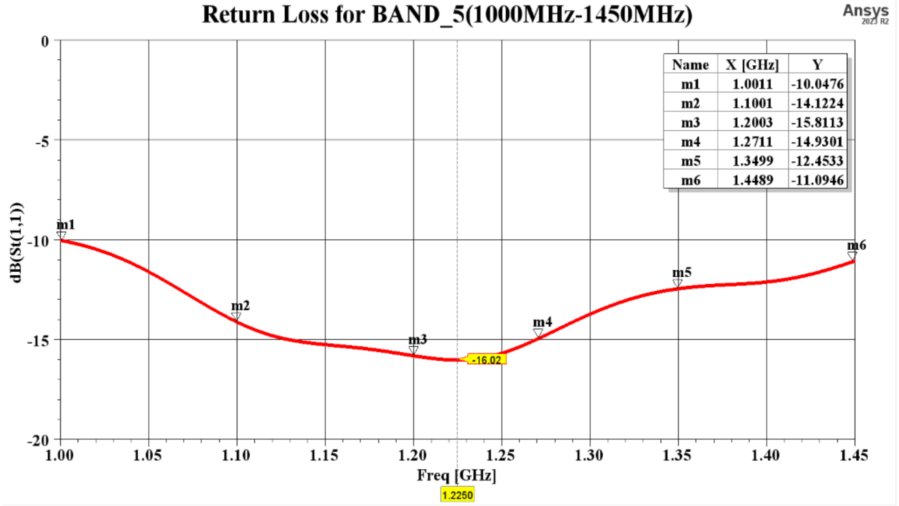
Return Loss:



Name	X [MHz]	Y
m1	120.0000	-11.2356
m2	161.1000	-13.8570
m3	185.4000	-16.7167
m4	207.6000	-20.4064
m5	226.8000	-28.7306
m6	240.0000	-18.1381

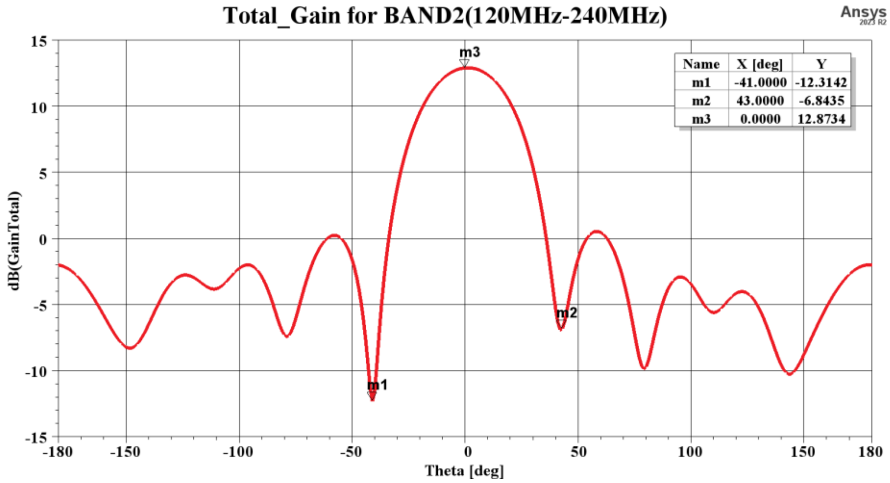


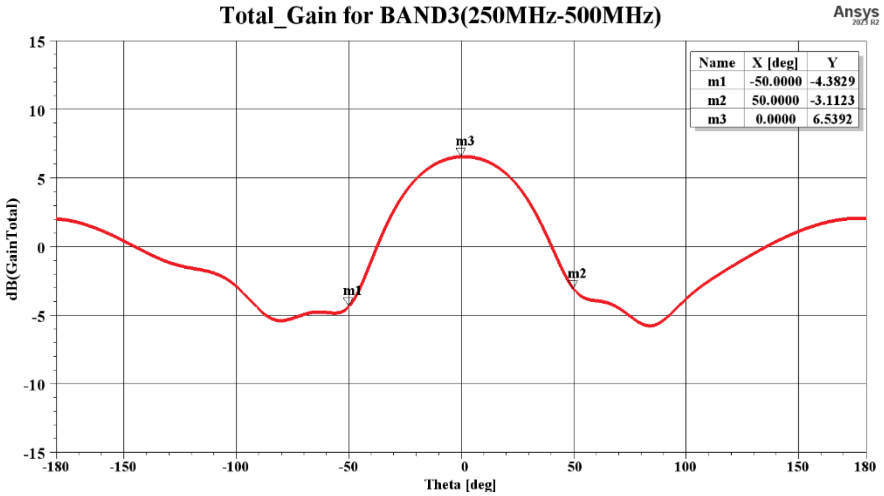
Name	X [MHz]	Y
m1	250.0000	-10.7986
m2	253.1250	-12.2358
m3	350.6250	-10.9664
m4	400.6250	-13.5463
m5	449.3750	-16.2960
m6	481.8750	-12.9344
m7	499.3750	-10.7958

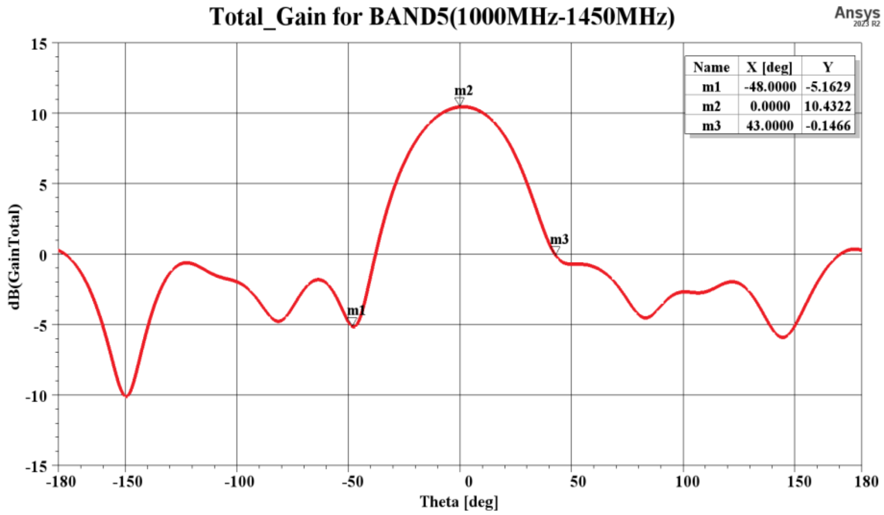


Name	X [GHz]	Y
m1	1.0011	-10.0476
m2	1.1001	-14.1224
m3	1.2003	-15.8113
m4	1.2711	-14.9301
m5	1.3499	-12.4533
m6	1.4489	-11.0946

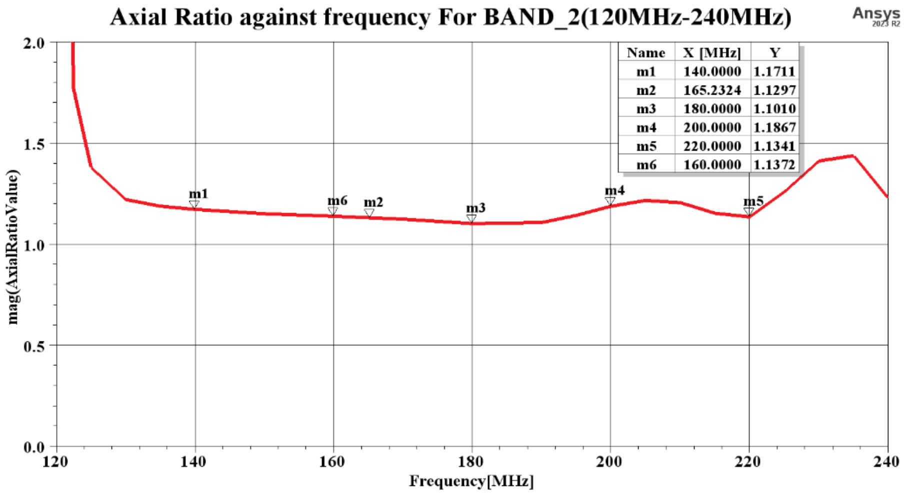
Gain:


Total_Gain for BAND2(120MHz-240MHz)
Ansys 2023 R2
Name | X [deg] | Y
m1 | -41.0000 | -12.3142
m2 | 43.0000 | -6.8435
m3 | 0.0000 | 12.8734
m1
m2
m3
dB(GainTotal)
15
10
5
0
-5
-10
-15
-180
-150
-100
-50
0
50
100
150
180
Theta [deg]

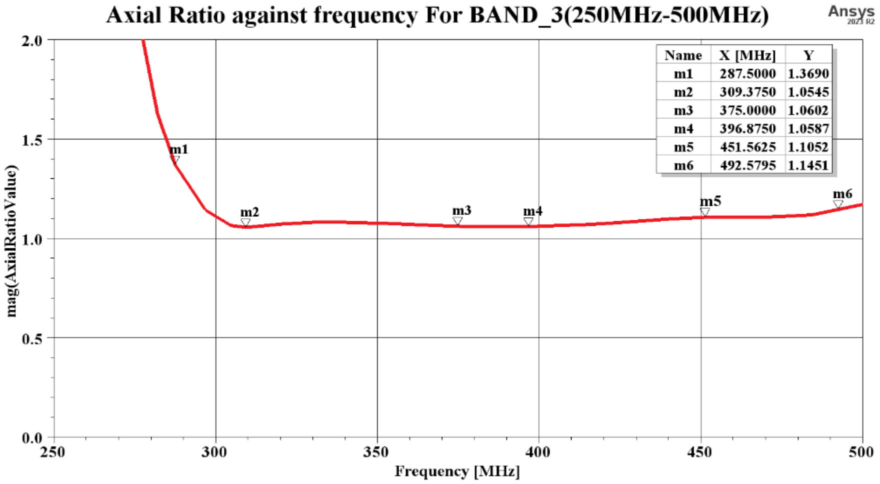

Total_Gain for BAND3(250MHz-500MHz)
Ansys 2023 R2
Name | X [deg] | Y
m1 | -50.0000 | -4.3829
m2 | 50.0000 | -3.1123
m3 | 0.0000 | 6.5392
m1
m2
m3
dB(GainTotal)
15
10
5
0
-5
-10
-15
-180
-150
-100
-50
0
50
100
150
180
Theta [deg]


Total_Gain for BAND5(1000MHz-1450MHz)
Ansys 2023 R2
Name | X [deg] | Y
m1 | -48.0000 | -5.1629
m2 | 0.0000 | 10.4322
m3 | 43.0000 | -0.1466
m1
m2
m3
dB(GainTotal)
15
10
5
0
-5
-10
-15
-180
-150
-100
-50
0
50
100
150
180
Theta [deg]

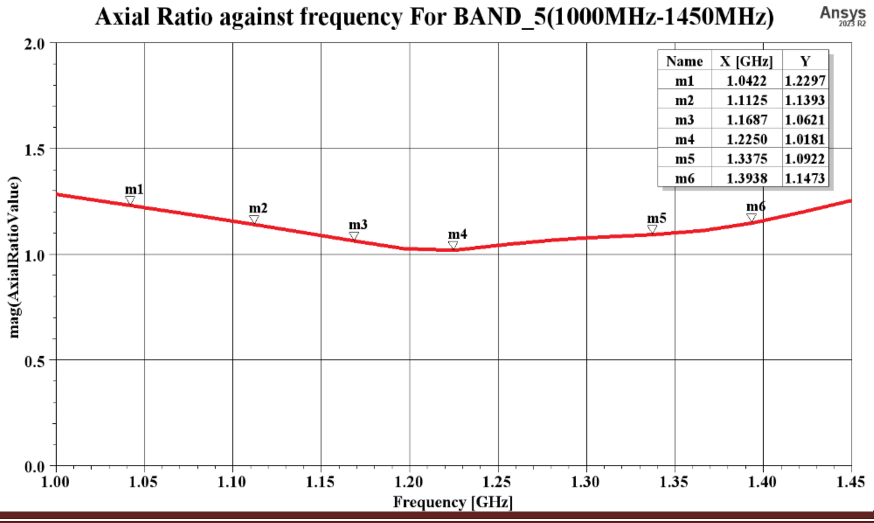
Axial Ratio:



Name	X [MHz]	Y
m1	140.0000	1.1711
m2	165.2324	1.1297
m3	180.0000	1.1010
m4	200.0000	1.1867
m5	220.0000	1.1341
m6	160.0000	1.1372



Name	X [MHz]	Y
m1	287.5000	1.3690
m2	309.3750	1.0545
m3	375.0000	1.0602
m4	396.8750	1.0587
m5	451.5625	1.1052
m6	492.5795	1.1451



Name	X [GHz]	Y
m1	1.0422	1.2297
m2	1.1125	1.1393
m3	1.1687	1.0621
m4	1.2250	1.0181
m5	1.3375	1.0922
m6	1.3938	1.1473

Applications:

- These antennas are applicable in satellite & space probe communications because of their circular polarization of the transmitted electromagnetic waves & maximum directivity.
- Polarization leakage can be tested using helical antenna.
- It can be used for checking satellite interference.
- It can be used for power line RFI measurement.
- A single or array of helical antennas are used for transmitting & receiving VHF signals. Also, as the Radio astronomy usage we can use Helical Antenna Array.
- Used for satellites at Earth stations.
- Used for telemetry links through ballistic missiles.
- Communication can be established between the moon & the earth.
- Helical antennas are used in many satellites like data relay and weather.
- This antenna is used for transmitting & receiving VHF waves, especially for ionospheric propagation.
- It is used for different communications like radio astronomy, space telemetry, satellite, and space.

Conclusion

This work presents design of axial mode helical antenna for both RHCP and LHCP for BAND4 using the ANSYS HFSS software. Also, we have mention the other helical antenna designs for u-GMRT bands results, with variations in helical antenna parameters and their effect on the return loss. Fabricated antenna is shown in this work, with the measured values. It has been seen that Measured values of parameters were close the simulation values. S11 for both RHCP and LHCP is lesser than -10 dB, VSWR for both is less than 2, Axial ratio for both is lesser than 1.5, Gain achieved is 11.9dB at center frequency 725MHz.

Similarly other bands helical antenna gives us the optimum results which we desired.

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[6] Tang, Xihui, Yejun He, and Botao Feng. "Design of a wideband circularly polarized strip-helical antenna with a parasitic patch." IEEE Access 4 (2016): 7728-7735.