



"1,5 - 40 GHz Meander Spiral Antenna Simulation and Design"

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Introduction

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- Design Methodology
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Application

- Electronic Support Measurement (ESM)
- Radar Warning Receiver (RWR)







Design Specification

- UWB Frequency Operation
- Accepted Field Polarization
- Gain Flatness
- HPBW Stability
- Return Loss
- Mechanical Constraints
- Reproducibility
- System Requirement

 f_{Max} : f_{min}

$$\rightarrow | LHCP - PO - PV$$

$$\rightarrow \quad Go_{dB}(f) \pm \Delta G$$

 $\rightarrow | HPBW(f) = HPBW_0 \pm \Delta \theta$

$$\rightarrow |S_{11}(f)| < So_{dB}$$

$$\rightarrow \left| \begin{array}{c} L_{Max} \times H_{Max} \times W_{Max} \right. \right.$$

- \rightarrow Industrialization
- → Target Cost; ...







Antenna Topology

Spiral Antennas are suitable for ESM/RWR System application

Typical Electrical Parameter

- $S_{0 dB}$ < -10 dB
- *HPBW*₀ ≈ 80 °
- G_{LHCP} ≈ 3 dBi
- Low Profile W_{Max}< R_{Max}
- Cross-polarization < -20dB @ Boresight







Numerical Approach

Mixed Potential Integral Equation (MPIE) Formulation of Maxwell Equation

$$\hat{n} \times (-j\omega \vec{A} - \nabla \phi) = \hat{n} \times Z_{S} \vec{J}$$

MoM applied to MPIE (ANSOFT Planar EM)

- Suitable for Planar Structure
- Tetrahedrical Mesh









Design Methodology

The Antenna Design is divided in two phases:

The three substructure Design

Feeding Circuit

Absorber material filled Cavity

Radiating Circuit



Complete spiral antenna analysis and total radiating element performances evaluation





Feeding Circuit Design (1/2)

The feeding circuit must provide a transition from an unbalanced guiding structure to a balanced ones (Balun)

In addition it must provide an impedance transformation to match the radiating circuit input impedance over the whole frequency bandwidth.







Balun Material: ARLON® AD600 ($\varepsilon_r = 6$) with thickness t = 0.508mm

S-parameter Simulation

 $|S_{11}(f)|$









Lossy Cavity Design

- The Backside Cavity is filled with Honeycomb Absorber (HC) to suppress the back radiation
- The HC Absorber has been modeled with three different uniform lossy dielectric layers.





Radiating Circuit Design(1/3)

General Equiangular Shape



- Self Complementary Structure
- Lower Losses

Archimedean Shape

 $r = r_0(\phi + \phi_0)$



- Stability of phase centre
- Improved Axial Ratio
- Wider operating frequency BW with a given antenna diameter







Combined Spiral Antenna







□ Meander Combined Spiral Antenna







Technology Choice

□ Antenna Dielectric Substrate Analysis

Current Density distribution(@2GHz) vs Dielectric substrate permittivity \mathcal{E}_r

$$r_a \cong rac{\lambda_{eff}}{2\pi}$$

 r_a = Radius of active region



Current Density distribution (@2GHz) vs Dielectric substrate Thickness H







Size Reduction





15% size reduction with Meandering last spiral wings





3D Antenna Layout

Simulated Antenna



Realized Antenna







NF to FF Measurement (1/3)

Near Field Measurements with STARLAB by SATIMO from 0.8 to 18 GHz Antenna











NF to FF Measurement (2/3)

Gain @ 5 GHz

Gain @ 4 GHz



sn002 freq =5 GHz, phi = 0rad Pattern_{phi} Pattern_{cta} Pattern_{cta} Pattern_{circolare} -5 -5 -5 -20 -25 -30 00 -80 -60 -40 -20 0 20 40 60 80 100 Teta (Ang)

Gain @ 13 GHz

Gain @ 8 GHz





Gain @ 18 GHz sn002 freq =18 GHz, phi = Orad













Far Field Measurement (1/2)

□ Far Field Measurements 18-40 GHz with Anechoic Chamber







Far Field Measurement (2/2)

E55

Gain @ 26 GHz



Gain @ 35 GHz



Gain @ 30 GHz



Gain @ 40 GHz













Broadband LHCP Gain @ Boresight







Gain @ 4 GHz



Gain @ 18 GHz



Gain @ 32 GHz



Gain @ 40 GHz







Conclusion

- The design of 1,5 40 GHz Meander Spiral Antenna has been performed using Planar EM by Ansoft
- **The Antenna Design has been divided in three substructure**:
 - Balun
 - The Absorber Filled Cavity
 - Circuit Layout
- Combining the Equiangular shape and the Archimedean shape we have avoided the drawbacks of each radiating structure.
- Meandering the last spiral turns we have obtained about 15% size Antenna reduction
- The simulated results are in good accordance with the measurements in terms of Return Loss, Gain and Pattern





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Design, Simulation and Measure of Broadband Cavity Backed Combined Spiral Antenna

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Optimization of a UWB Vivaldi Antenna Array and Measurements with a Near Fields STARLAB System and Farfield Anechoic Chamber

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