URSI GASS 2020, Rome, Italy, 29 August - 5 September 2020

Novel Miniaturized Sinuous Antenna for UWB Applications

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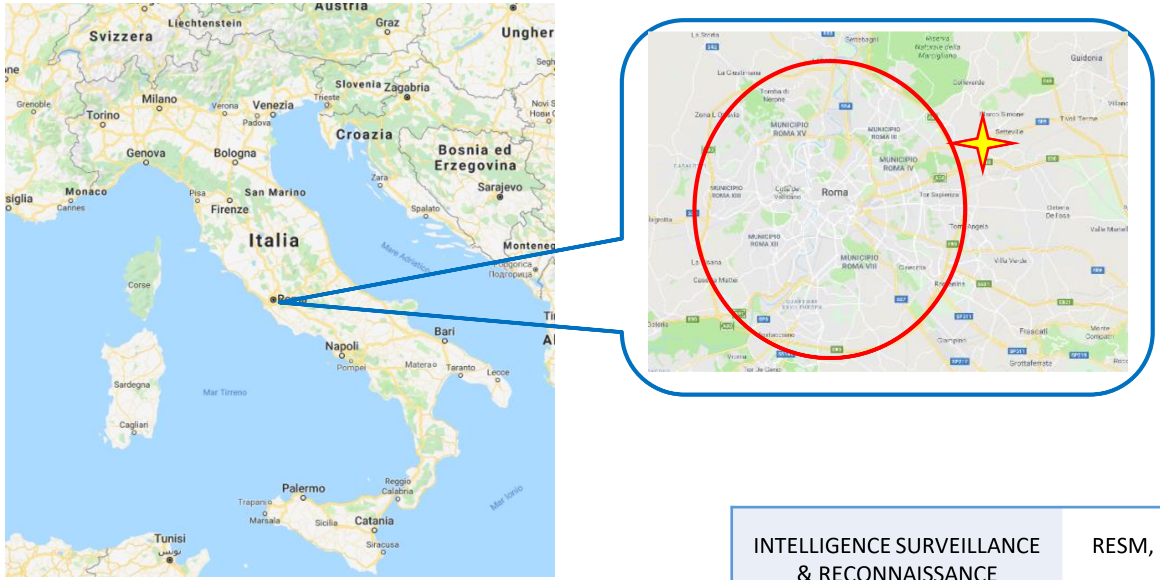

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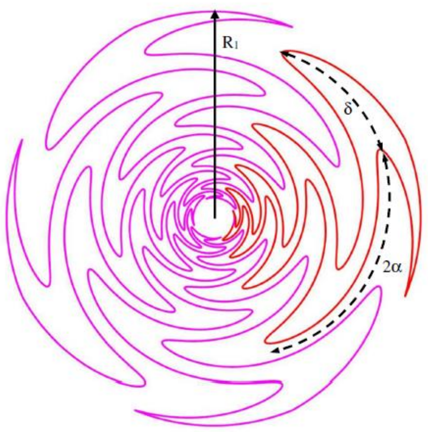
Summary

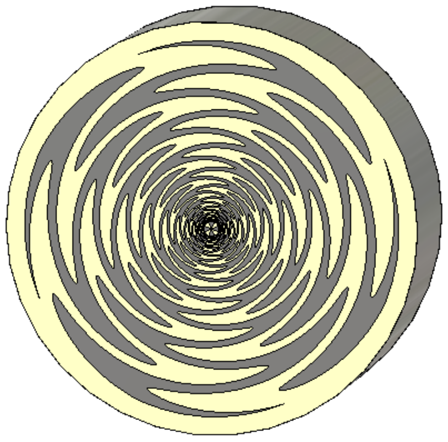
- Introduction to the Sinuous Antenna
- Sinuous Antenna Design
  - Standard Sinuous Antenna
  - Non-Conventional Cavity Backed Sinuous Antenna
- Analysis and Simulation Results
  - Performance
- Conclusions

Introduction to the Sinuous Antenna

The operation principle of the Sinuous Antenna is described in the following picture:

- Multiple folded dipoles
- Self-complementary structure → frequency independent performance
- The UWB behavior is realized by means of dipoles that resonate at adjacent frequencies

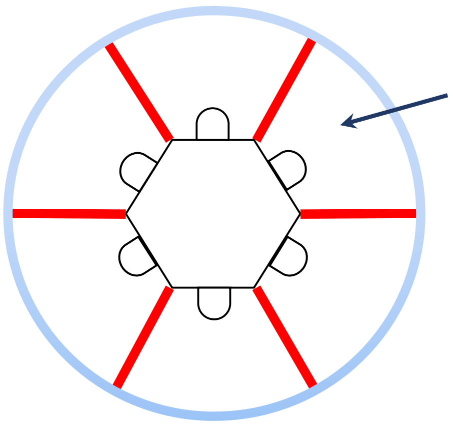




Introduction to the Sinuous Antenna

The electromagnetic sensor should have the following capabilities :

- UWB Functionality
- Controlled HPBW
- S45 Polarization
- Light Weight
- Small Dimensions
- Direction Finding Application



$$x = t * \cos\left(-1^{p}\alpha \quad \sin\left(\pi \left| \frac{\ln\left(\frac{t}{R_p}\right)}{\ln(\tau_p)} \right| \right) \pm \delta \right)$$

$$y = t * \sin\left(-1^{p}\alpha \quad \sin\left(\pi \left| \frac{\ln\left(\frac{t}{R_p}\right)}{\ln(\tau_p)} \right| \right) \pm \delta \right)$$

Parameters:

$R_s < t < R_p$

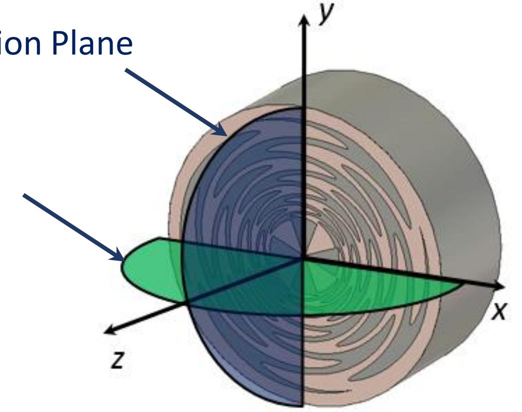
R_s minimum radius

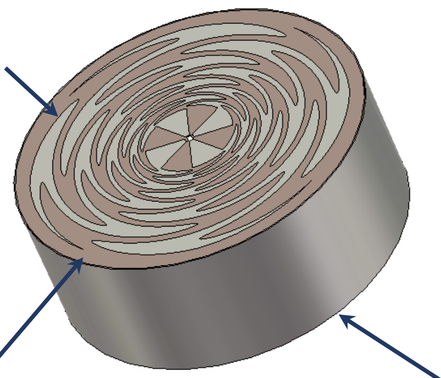
R_p maximum radius

τ_p expanction factor

δ arm thickness

α arm angular width

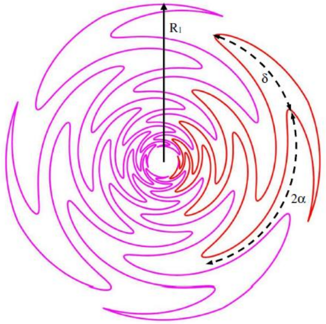


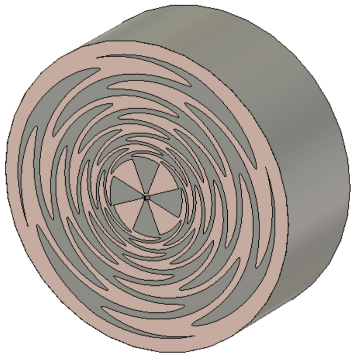


Introduction to the Sinuous Antenna

4-Arm Sinuous Antenna Properties:

- 2-18 GHz
- Controlled HPBW
- S45 Polarization
- 6 cm Diameter





$$x = t * \cos\left(-1^{p}\alpha \quad \sin\left(\pi \left| \frac{\ln\left(\frac{t}{R_p}\right)}{\ln(\tau_p)} \right| \right) \pm \delta \right)$$

$$y = t * \sin\left(-1^{p}\alpha \quad \sin\left(\pi \left| \frac{\ln\left(\frac{t}{R_p}\right)}{\ln(\tau_p)} \right| \right) \pm \delta \right)$$

Parameters:

$R_s < t < R_p$

R_s minimum radius

R_p maximum radius

τ_p expanction factor

δ arm thickness

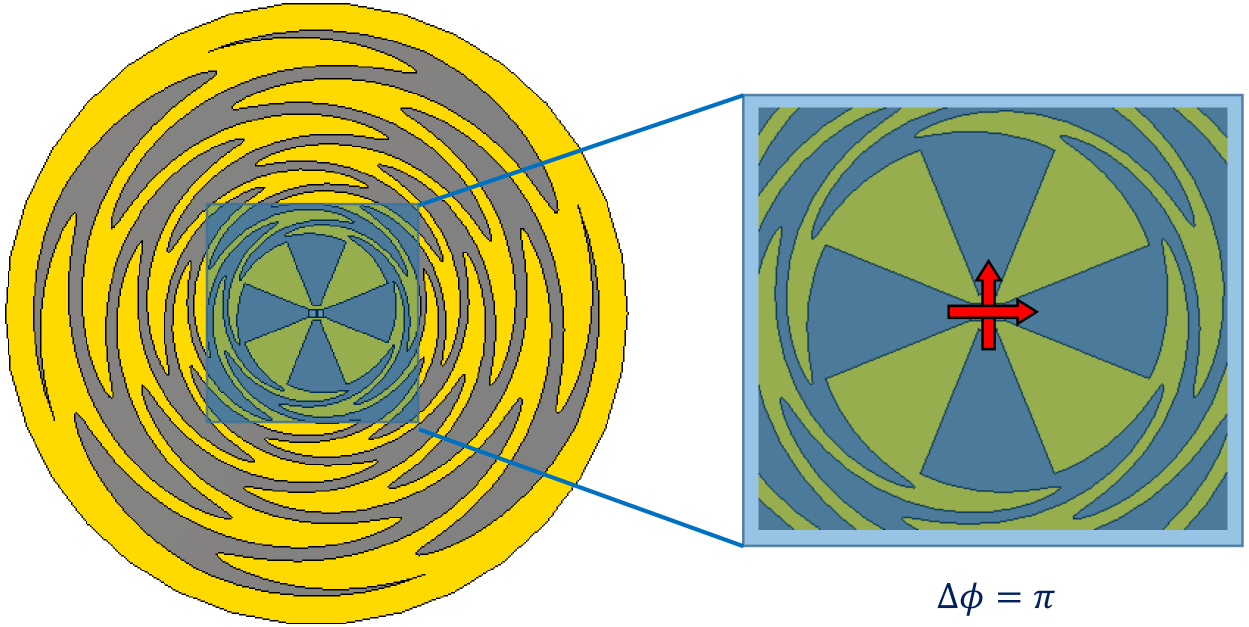
α arm angular width

The goal is to lower the minimum frequency operation maintaing the same diameter considering:

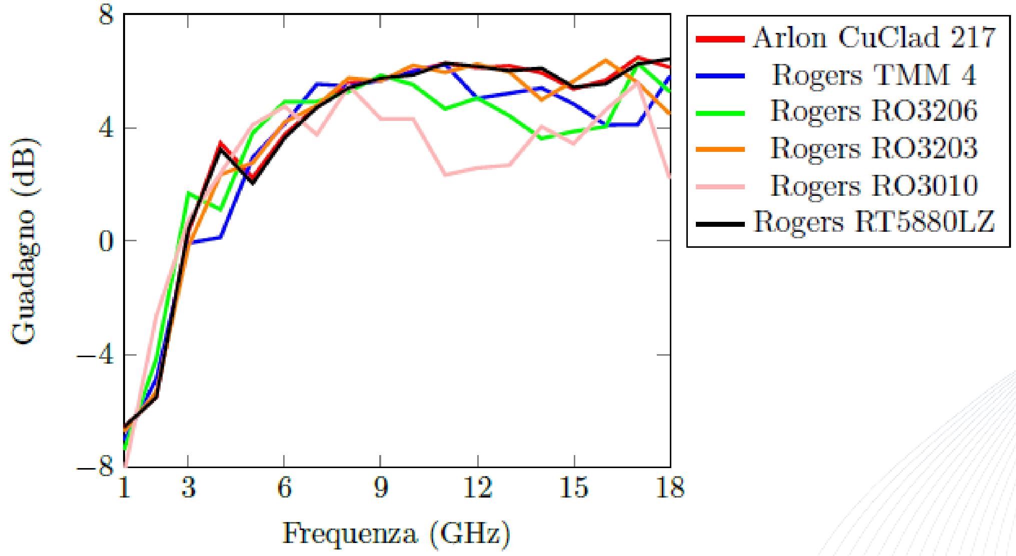
- S11 < -5 dB
- Gain > -5 dBi
- HPBW < 120°

Free Space Sinuous Antenna – Substrate Investigation

The best choice is Rogers RT5880LZ

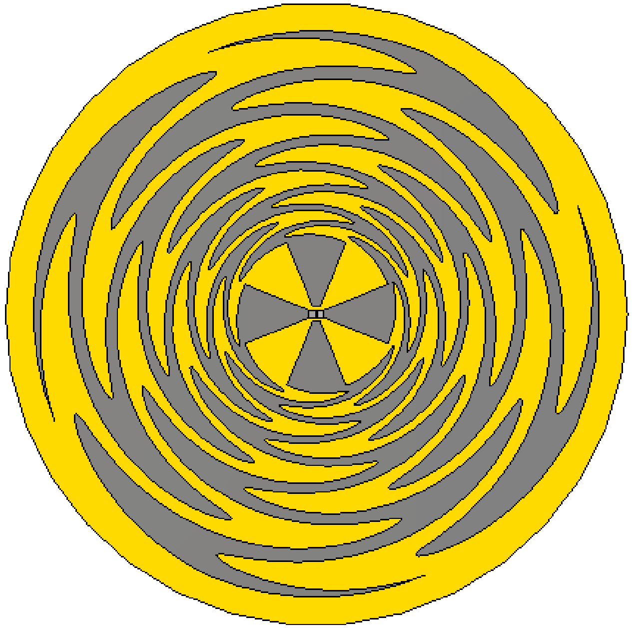


$\Delta\phi = \pi$

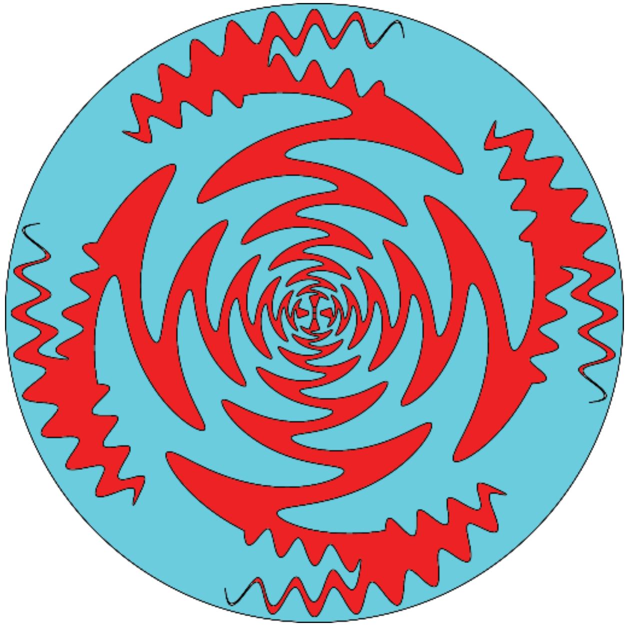


Free Space Sinuous Antenna – Meandering

Classical Sinuous Antenna



Meandered Sinuous Antenna



The meandering increases the electrical lenght of the arms introducing a corss-pol contribute

Free Space Sinuous Antenna – Meandering

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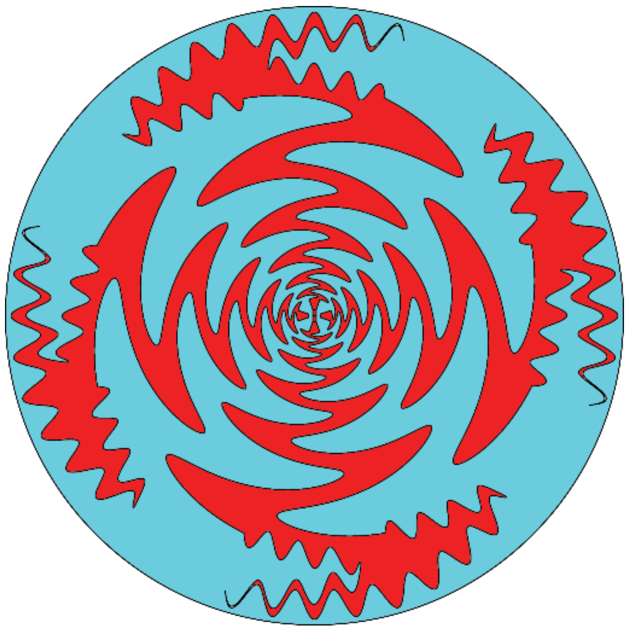
Meandered Sinuous Antenna



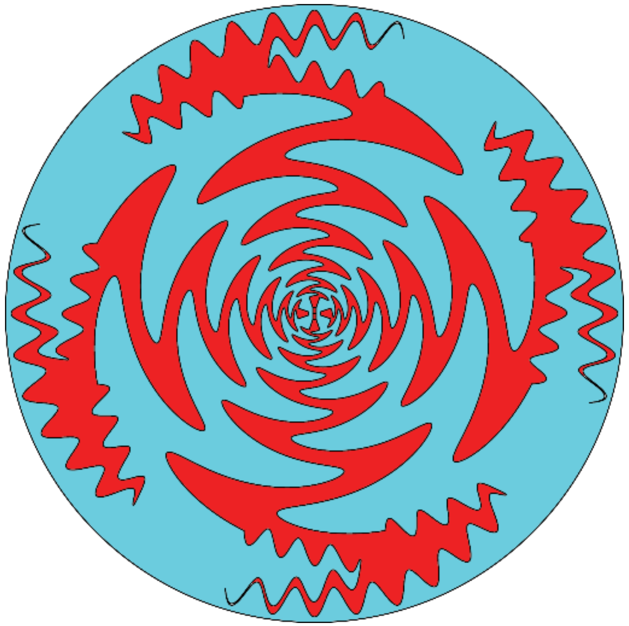
$$x = \begin{cases} t * \cos\left(-1^{p}\alpha \quad \sin\left(\pi\left|\frac{\ln\left(\frac{t}{R_p}\right)}{\ln(\tau_p)}\right|\right) \pm\delta\right) & R_s < t < R_d \\ t * \cos\left(-1^{p}\alpha \quad \sin\left(\pi\left|\frac{\ln\left(\frac{t}{R_p}\right)}{\ln(\tau_p)}\right|\right) \pm\delta\right) * \left[1 + x_p \cos\left(\xi * \left(-1^{p}\alpha \quad \sin\left(\pi\left|\frac{\ln\left(\frac{t}{R_p}\right)}{\ln(\tau_p)}\right|\right) \pm\delta\right)\right)\right] & R_d < t < R_p \end{cases}$$

$$y = \begin{cases} t * \sin\left(-1^{p}\alpha \quad \sin\left(\pi\left|\frac{\ln\left(\frac{t}{R_p}\right)}{\ln(\tau_p)}\right|\right) \pm\delta\right) & R_s < t < R_d \\ t * \sin\left(-1^{p}\alpha \quad \sin\left(\pi\left|\frac{\ln\left(\frac{t}{R_p}\right)}{\ln(\tau_p)}\right|\right) \pm\delta\right) * \left[1 + x_p \cos\left(\xi * \left(-1^{p}\alpha \quad \sin\left(\pi\left|\frac{\ln\left(\frac{t}{R_p}\right)}{\ln(\tau_p)}\right|\right) \pm\delta\right)\right)\right] & R_d < t < R_p \end{cases}$$

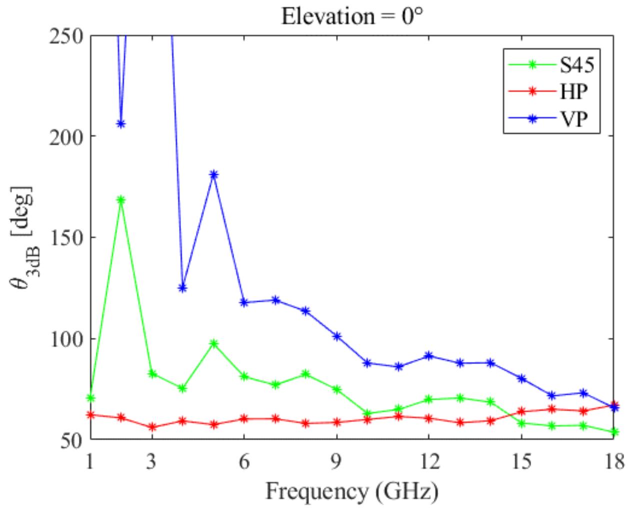
Parameter:
$R_s < t < R_p$
R_s minimum radius
R_p maximum radius
τ_p expanction factor
δ arm thickness
α arm angular width
x_p meander amplitude
ξ meander number

Free Space Sinuous Antenna – Meandering

HPBW on the Azimuth Plane

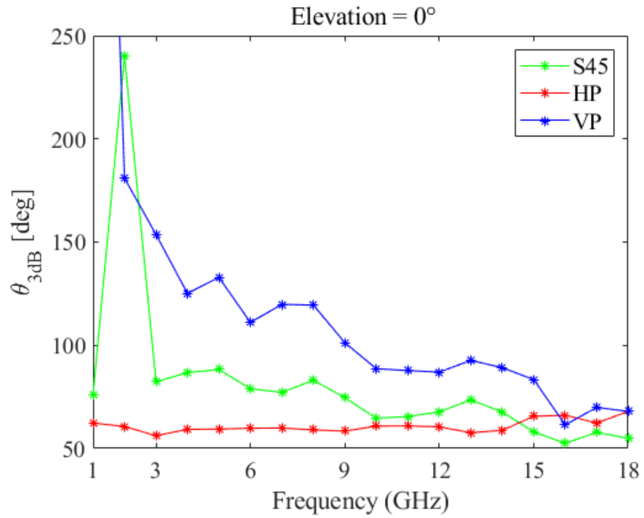


Classical Sinuous Antenna



Parameter:
R_p maximum radius = 60 mm
τ_p expanction factor = 0.79
δ arm thickness = π/10
α arm angular width = π/10
x_p meander amplitude = 0
ξ meander number = 0

Meandered Sinuous Antenna



Parameter:
R_p maximum radius = 60 mm
τ_p expanction factor = 0.79
δ arm thickness = π/10
α arm angular width = π/10
x_p meander amplitude = 0.05
ξ meander number = 40

Free Space Sinuous Antenna – Sharp ends

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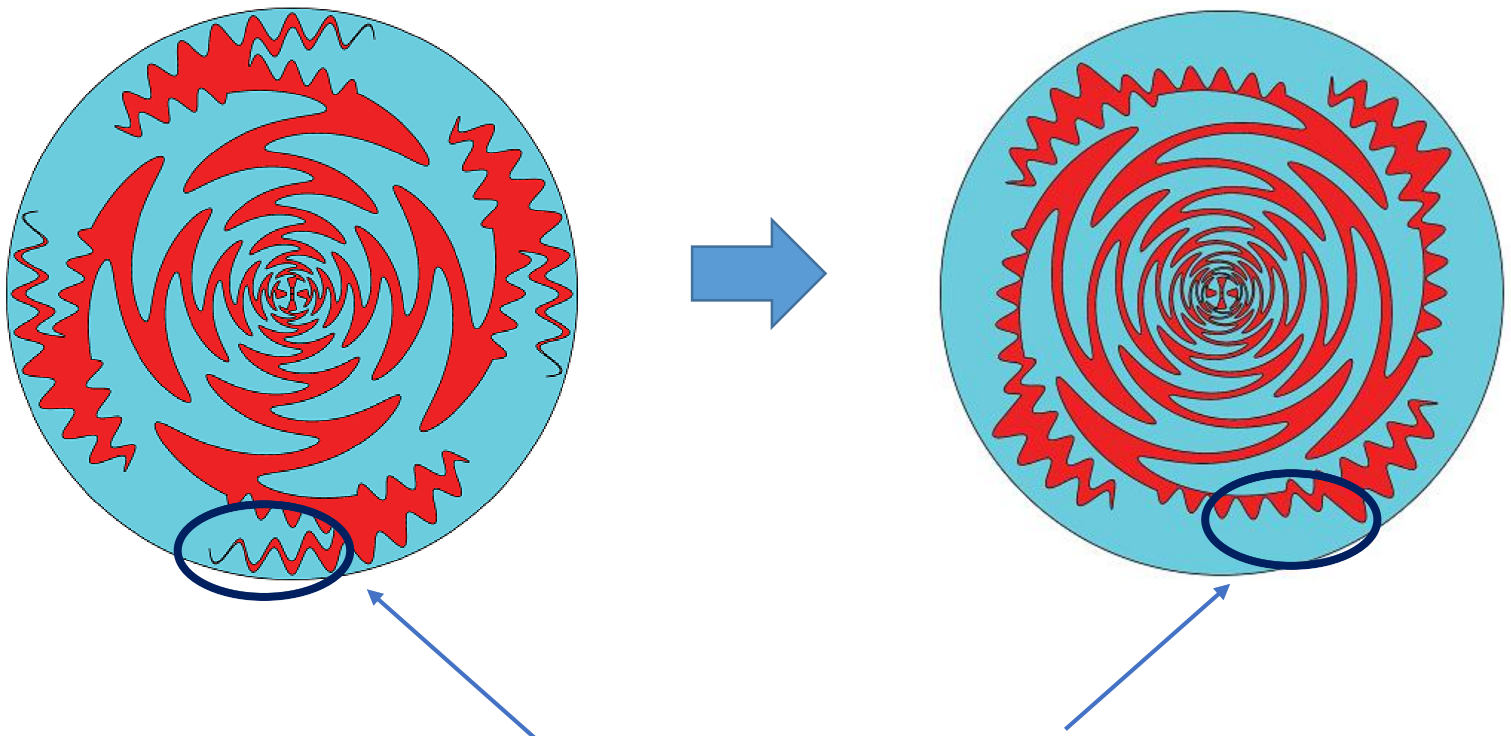
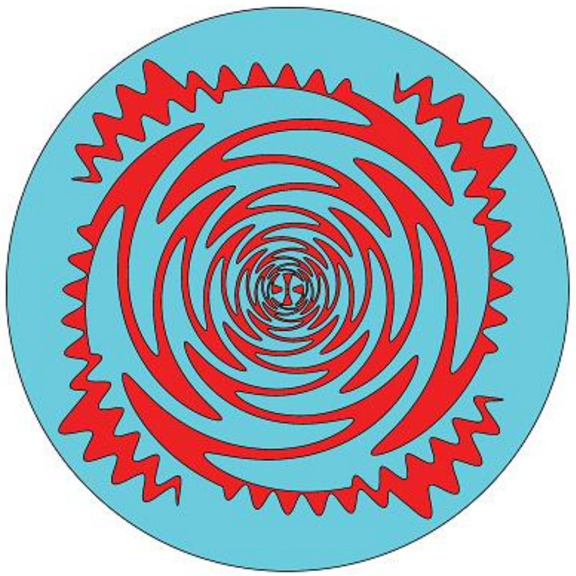
Optimized sharp ends

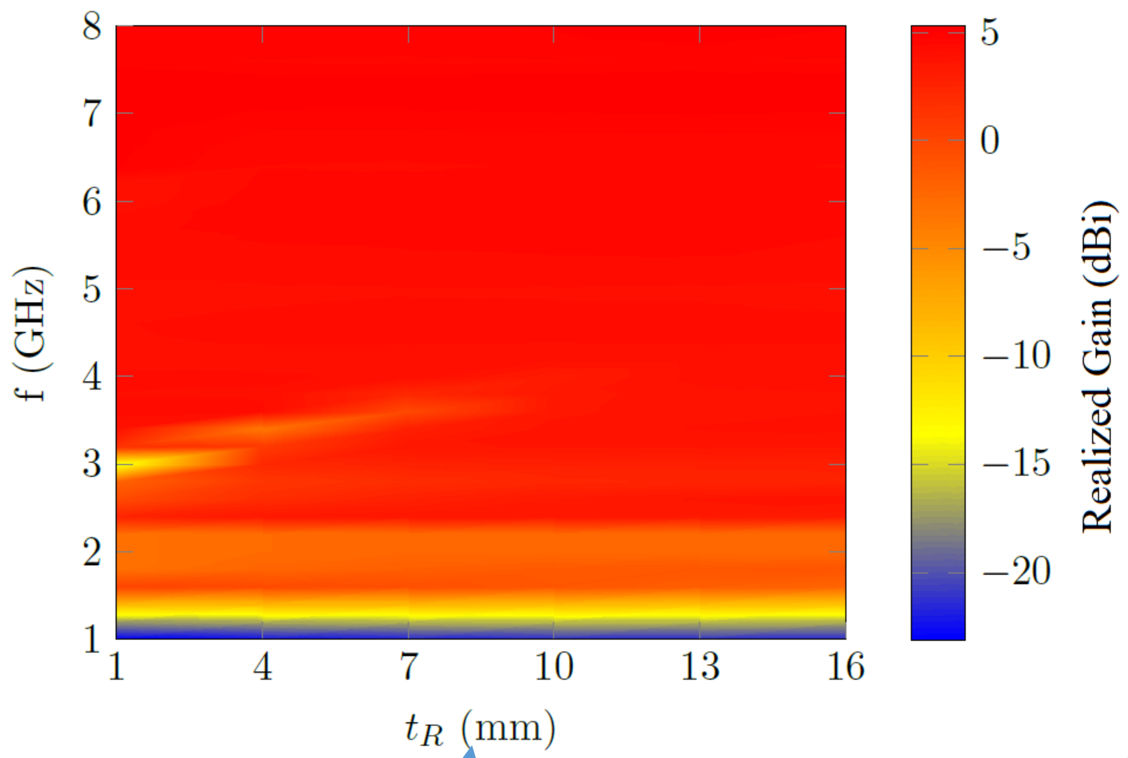


reduction of the sharp ends t_R [mm]

Free Space Sinuous Antenna – Sharp ends

Optimized sharp ends



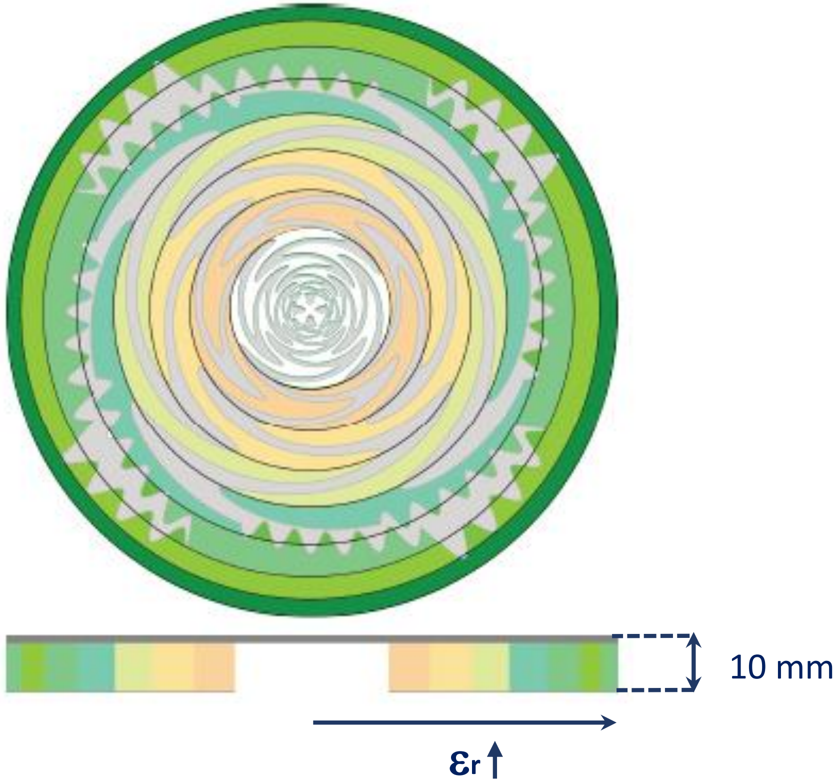


reduction of the sharp ends

For $t_R > 10$ mm the increases the gain at low frequency and the flatness in band

Free Space Sinuous Antenna – Substrate

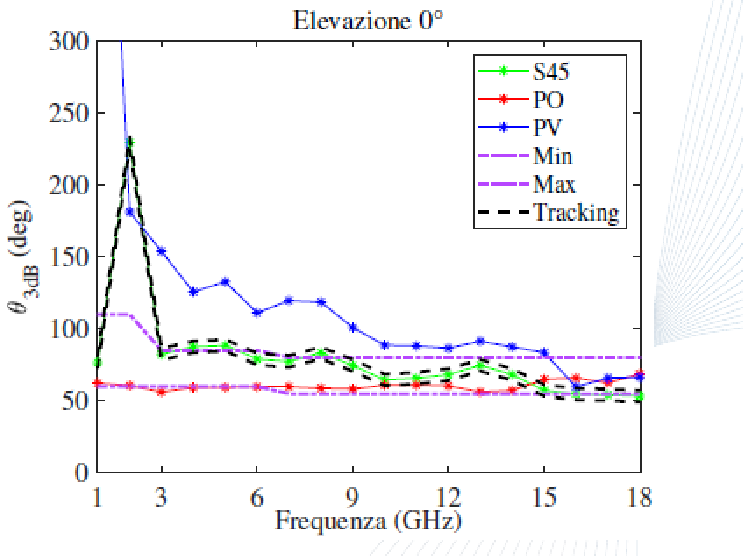
Dielectric Cylinder Loading



d	ε_r
$d_1 = 5.5$	$\varepsilon_{r1} = 1.5$
$d_2 = 5$	$\varepsilon_{r2} = 2$
$d_3 = 4.5$	$\varepsilon_{r3} = 2.5$
$d_4 = 4$	$\varepsilon_{r4} = 3$
$d_5 = 3.5$	$\varepsilon_{r5} = 3.5$
$d_6 = 3$	$\varepsilon_{r6} = 4$
$d_7 = 2.5$	$\varepsilon_{r7} = 5$
$d_8 = 2$	$\varepsilon_{r8} = 6$

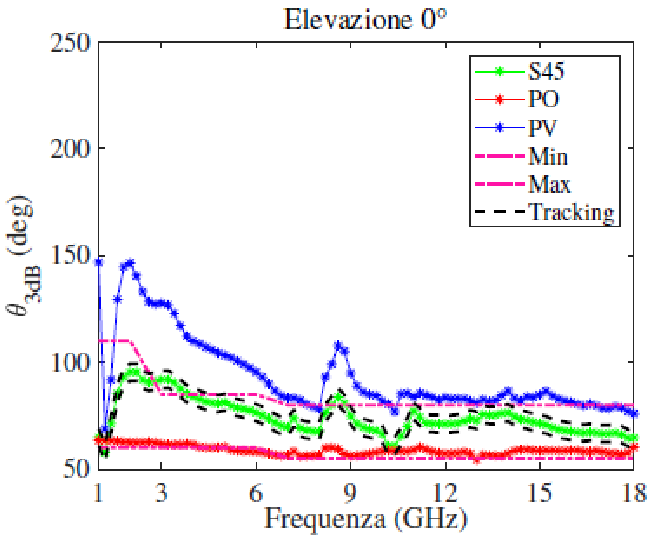
Free Space Sinuous Antenna – Substrate Loading

Meandered Sinuous Antenna



Parameter:
R_p maximum radius = 60 mm
τ_p expanction factor = 0.79
δ arm thickness = π/10
α arm angular width = π/10
x_p meander amplitude = 0.05
ξ meander number = 40

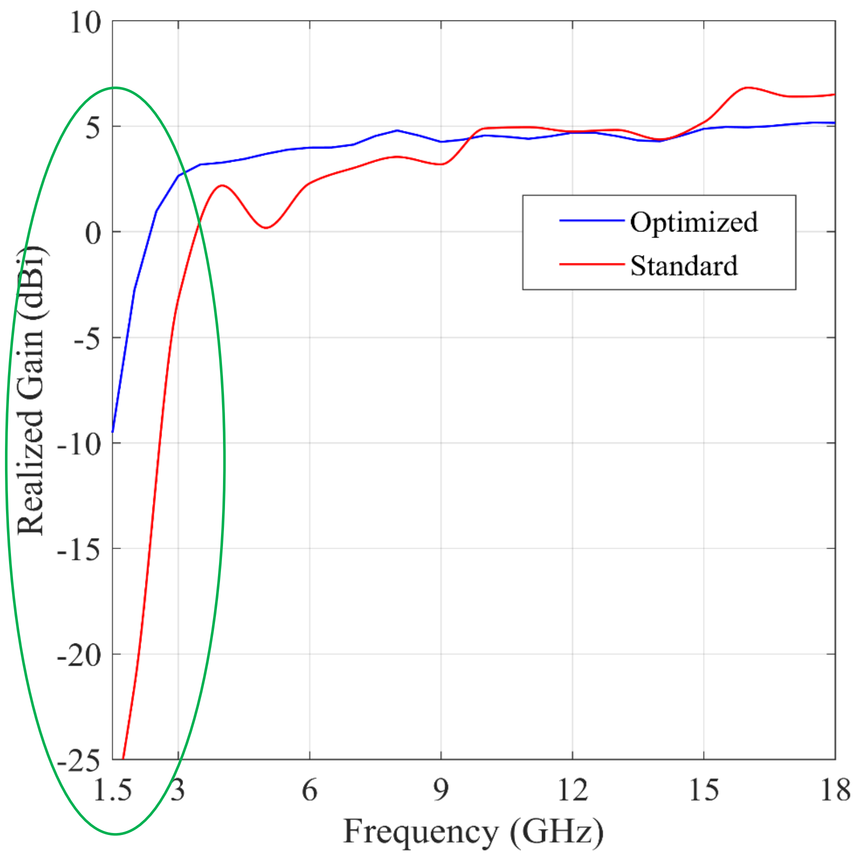
Meandered Sinuous Antenna with dielectric loading



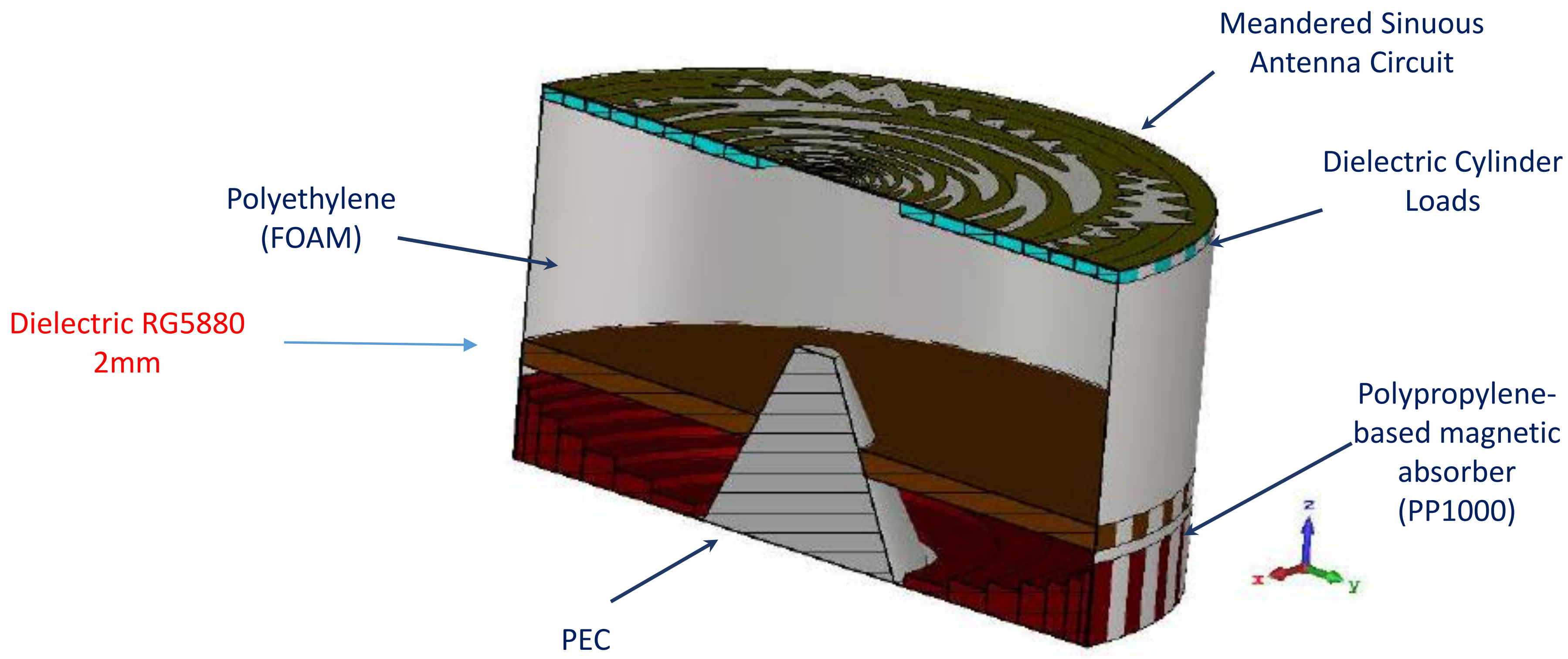
Free Space Sinuous Antenna – Substrate Loading

S45 Realized gain comparison

Reduction of the minimum working frequency from 2.9 to 1.5 GHz

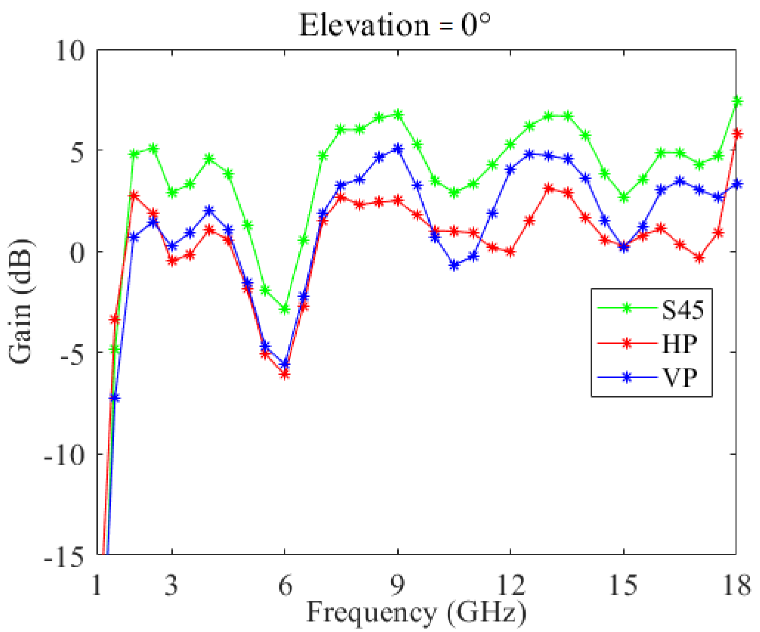


Optimized Cavity Backed Sinuous Antenna

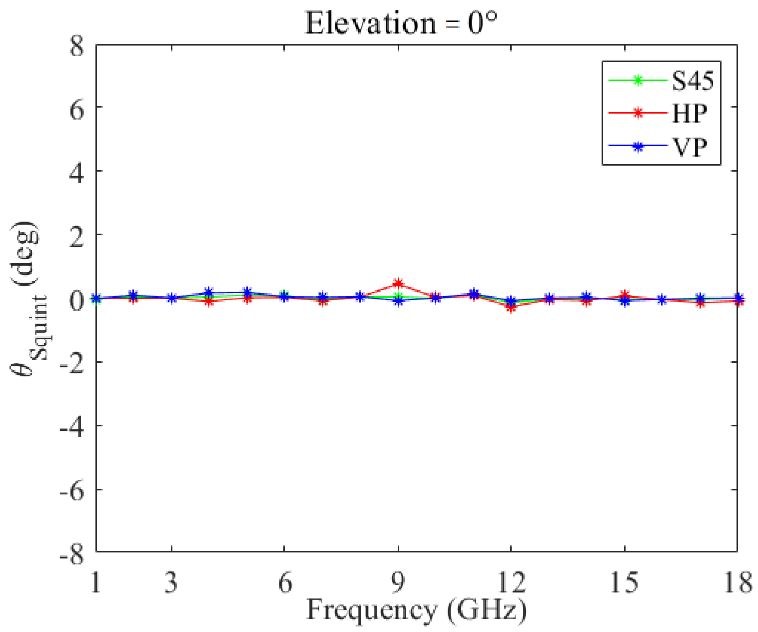


Optimized Cavity Backed Sinuous Antenna

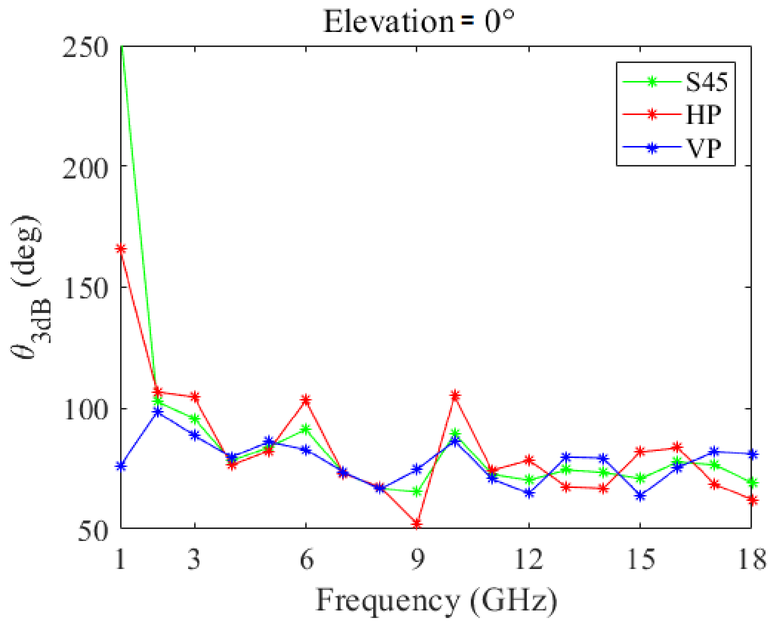
Boresight Realized Gain



Squint

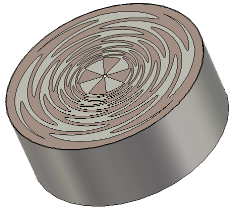


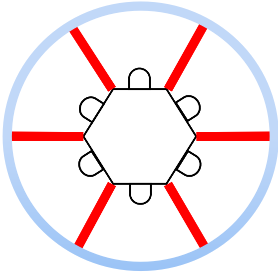
HPBW

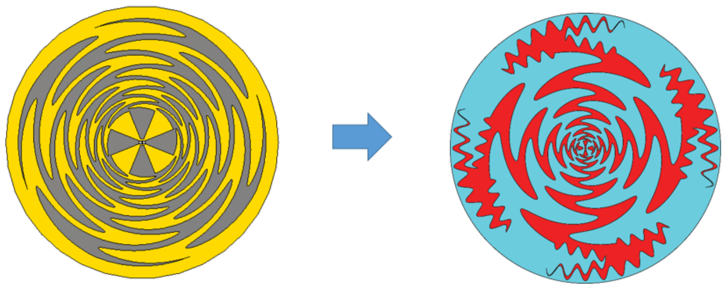


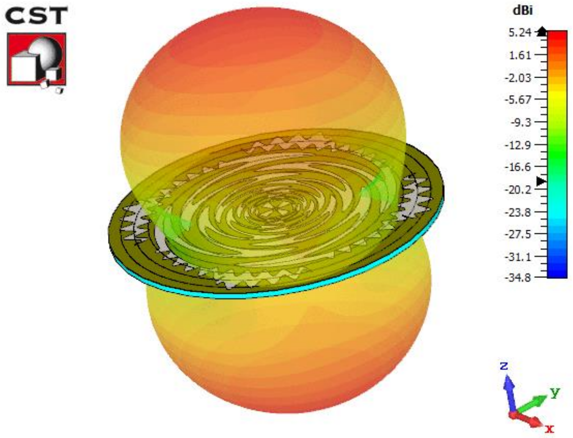
Conclusions

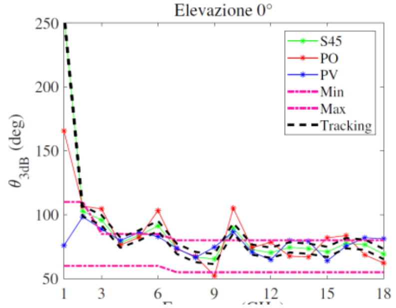
- ✓ Introduction to the Sinuous Antenna
- ✓ Design
  - Substrate Investigation
  - Meandered Shape
  - Dielectric loads
  - Cavity Backed Sinuous Antenna
- ✓ Simulation Results
  - HPBW on the Azimuth Plane
  - S45 Boresight Realized Gain
  - Squint

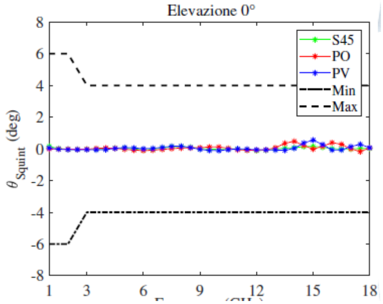


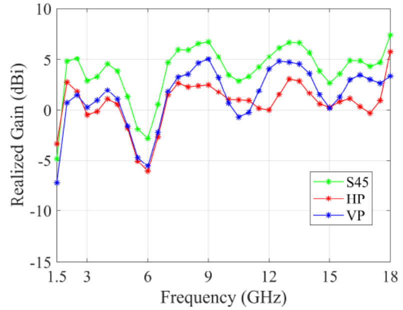












Thank you for the attention!

Any questions?

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