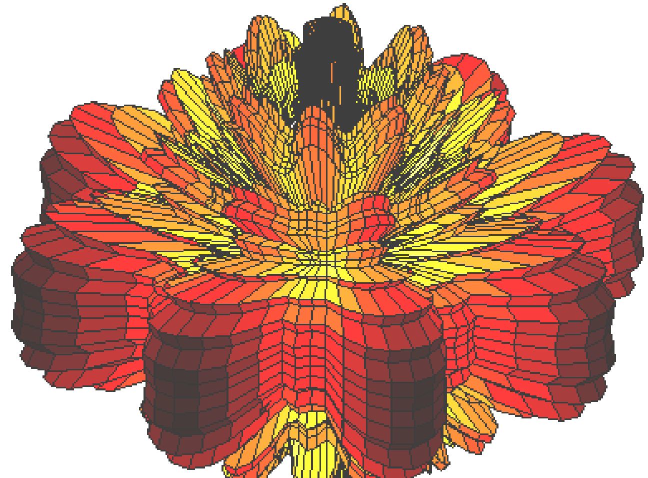
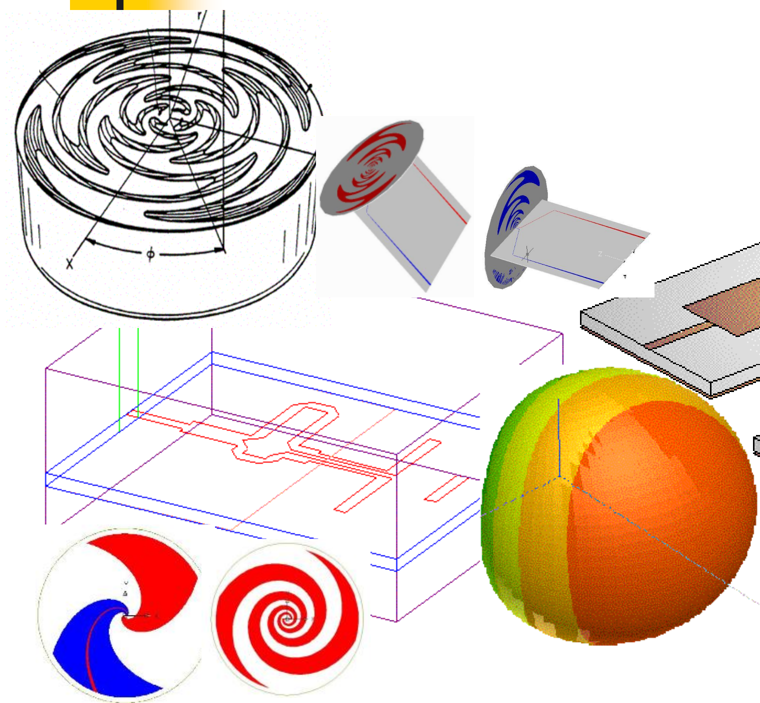


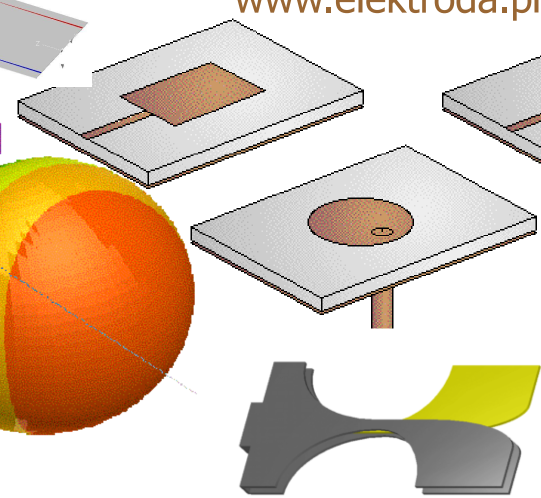
Broadband Planar Antennas

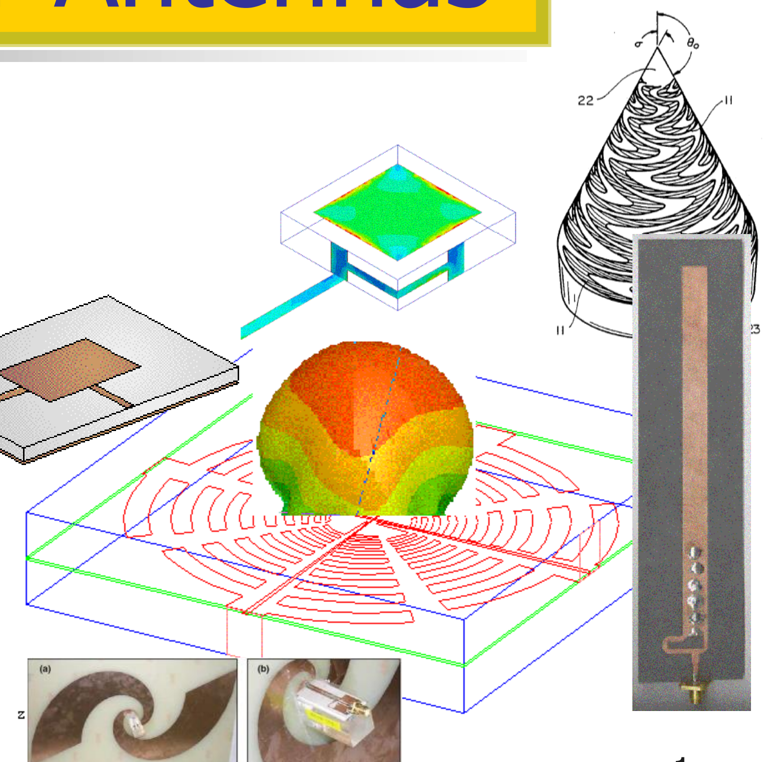
By:

KMPA

www.elektroda.pl





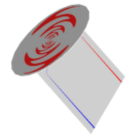


Outline

- History of Antenna.
- What is a planar antenna?
- Definitions of Bandwidth
- Planar Antenna will be Reviewed
  - Resonant Antenna.
  - Traveling-wave (Leaky-wave) antenna.
  - Slot antenna.
  - Tapered Slot antenna.
  - Quasi-Yagi antenna.
  - Foursquare antenna.
  - Frequency independent antenna:
    - Spiral Antenna.
    - Log-periodic antenna.
    - Sinuous antenna.

History of Antenna

- In 1842, Joseph Henry used vertical wires on the roof of his house to detect lightning flashes.
- In 1864, Clerk Maxwell presents his equations.
- In 1885, Thomas Edison patented a communications system that utilized top-loaded, vertical antennas for telegraphy.
- In 1887, Heinrich Hertz used his “Hertzian dipole” to validate Maxwell’s claim that electromagnetic waves propagate through the air
- In 1898, Marconi is generally credited with developing commercially and pioneering transcontinental communications.



Sinuous antenna

The sinuous antennas have a common usage in military and civil applications such as :

- Direction finding systems
- Reflectors feeds
- Polarimeter applications
- Radar Warning Receiver (RWR)
- Source Antennas with Low RCS for RF Anechoic Chambers

because of their:

1. Superior Broadband Characteristics
2. Simultaneous Dual linear Polarization Capability.

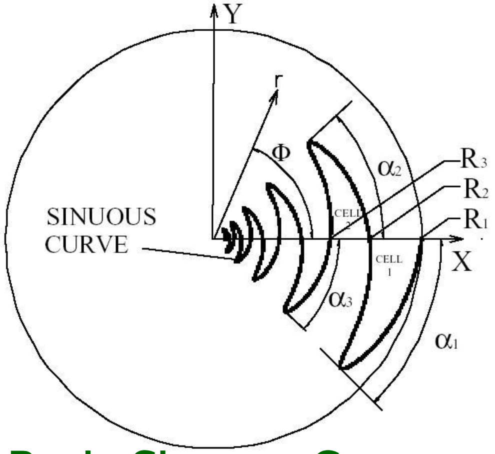
Sinuous antenna (Basic Idea)

- Victor H. Rumsey developed a principle that is : The impedance and pattern properties of an antenna will be frequency independent if The antenna shape is specified only in terms of angles.

- In 1982, R.H. DuHamel conceived an element called the **sinuous antenna.** The sinuous concept evolved from the idea that
  - A current distribution, circumferential in nature, could help to solve the E/H-plane pattern-uniformity problem,
  - An interleaved structure could lead to a small frequency-independent antenna,
  - A self-complementary structure would lead to a frequency-independent input impedance.

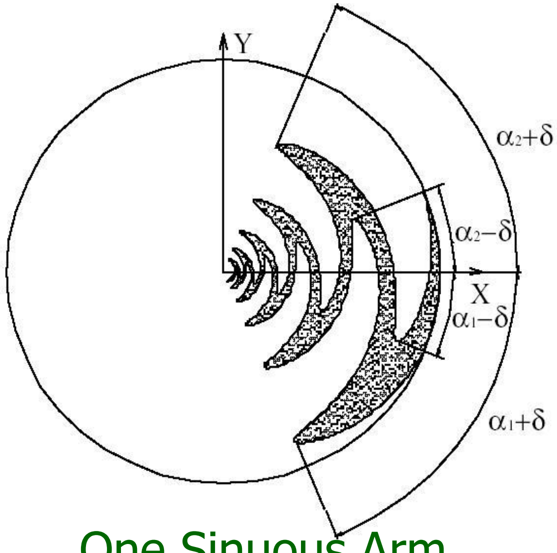
Sinuous antenna (Basic Geometry)

- The Sinuous antenna has four arms rotated at 90° relative to each other. The four arms circularly oscillate ±45° with increasing distance from the center.



Basic Sinuous Curve

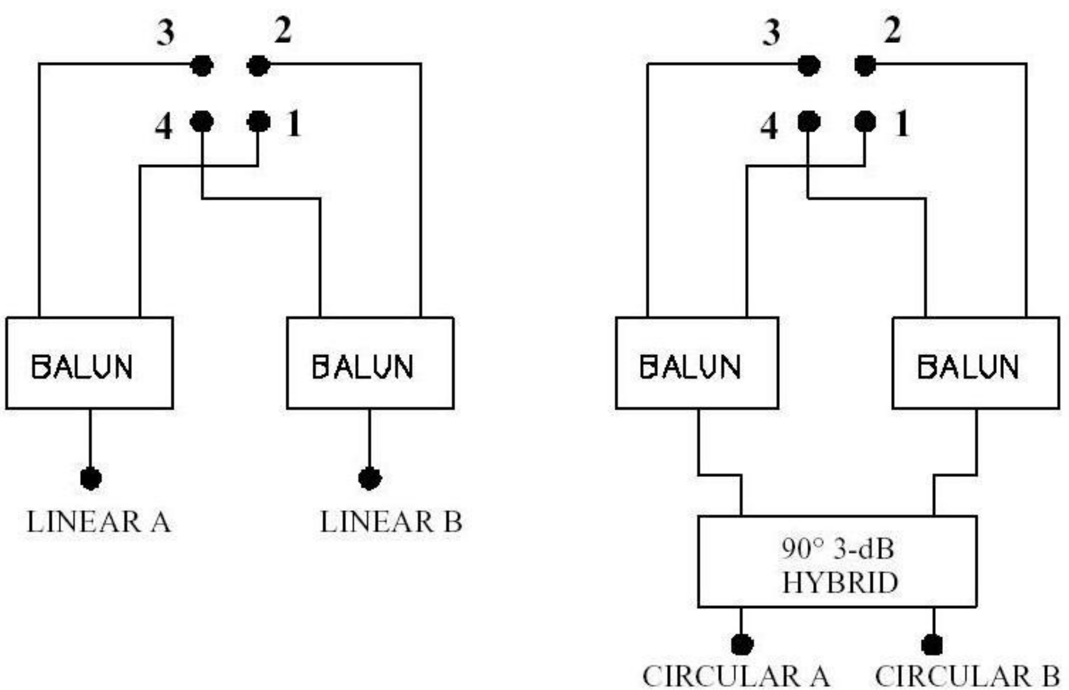
Four Arm Sinuous Antenna



One Sinuous Arm

Sinuous antenna (polarization senses)

- To form orthogonally linear polarized beams from this aperture, opposite arms are fed 180° out of phase at the central portion of the arms.
- The two senses of Circular polarization can be developed by combining the two linearly polarized beams in plus and minus 90° phase rotation using 3-dB 90° hybrid.



Sinuous antenna (Design Considerations)

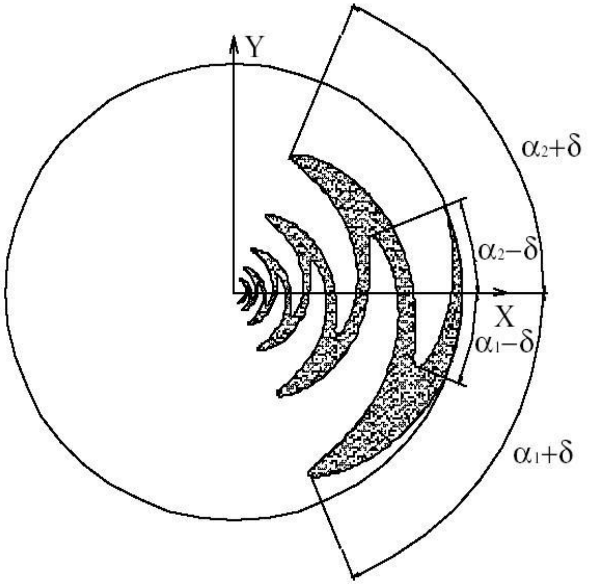
Limits for ensure good performance:

1. interleaving between arms less than 70 degree ➔ $\alpha + \delta < 70^0$
2. Expansion ratio must be greater then 0.65 ➔ $\tau_p < 0.65$
3. The self-complementary aperture has demonstrated consistent performance in gain and pattern characteristics.

$$\alpha = 45^o, \delta = 22.5^o$$

⬇

Optimum Self-Complementary structure

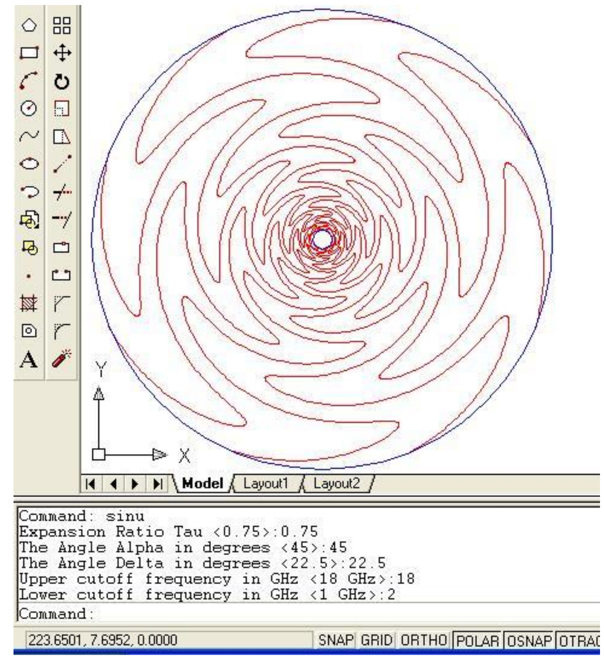


Sinuous antenna (Basic Equation)

- Equation :

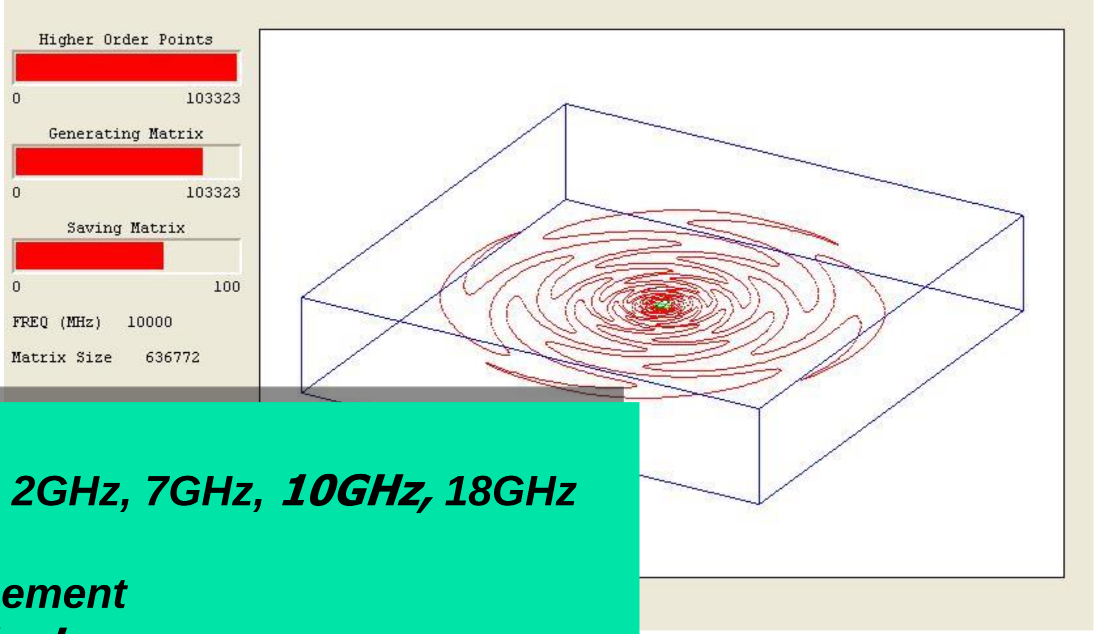
$$\varphi = (-1)^{p}\,\alpha_{p} Sin\left[\frac{180 Ln\left(\frac{r}{R_{p}}\right)}{Ln\left(\tau_{p}\right)}\right]$$

- An AutoLisp Code in AutoCAD 2002 environment developed for drawing of Any sinuous antenna with specified Characteristics and frequency range and expansion rate.



Sinuous antenna (Design Considerations)

- A prototype Optimum Sinuous Antenna in the frequency range of 2-18GHz designed by this code. The DXF file imported to Ansoft HFSS Ver8.0.21 and simulated.

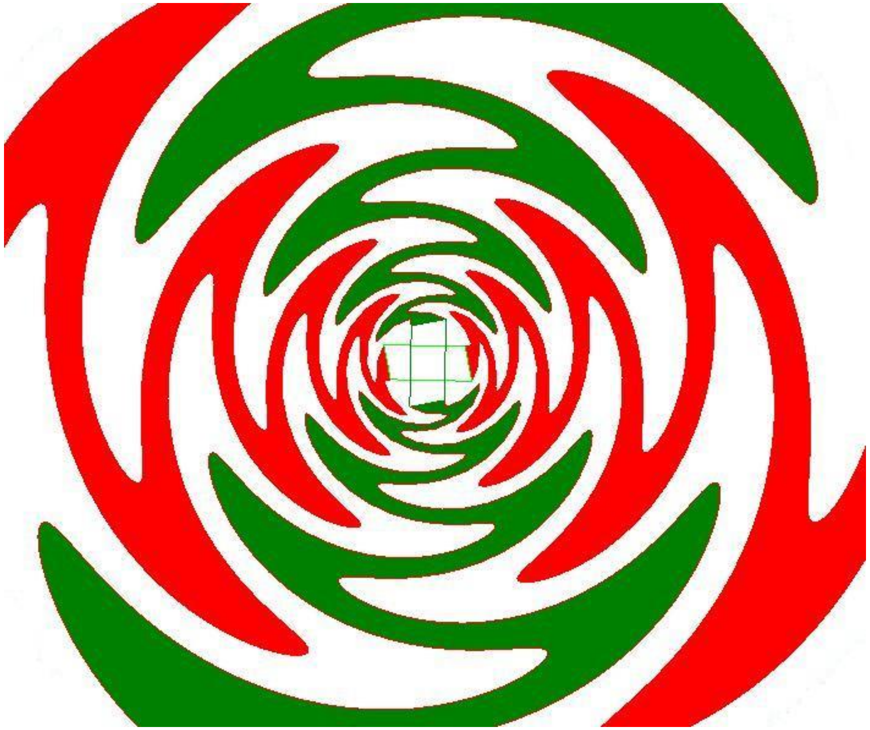


- ***SOLUTION SETUP***

8 Meshing Passes @ 2GHz, 7GHz, 10GHz, 18GHz
Max. Delta S : 0.6
20% Tetrahedra Refinement
about 95,000 Tetrahedra,
Single frequency simulation
about 3 hours on P4

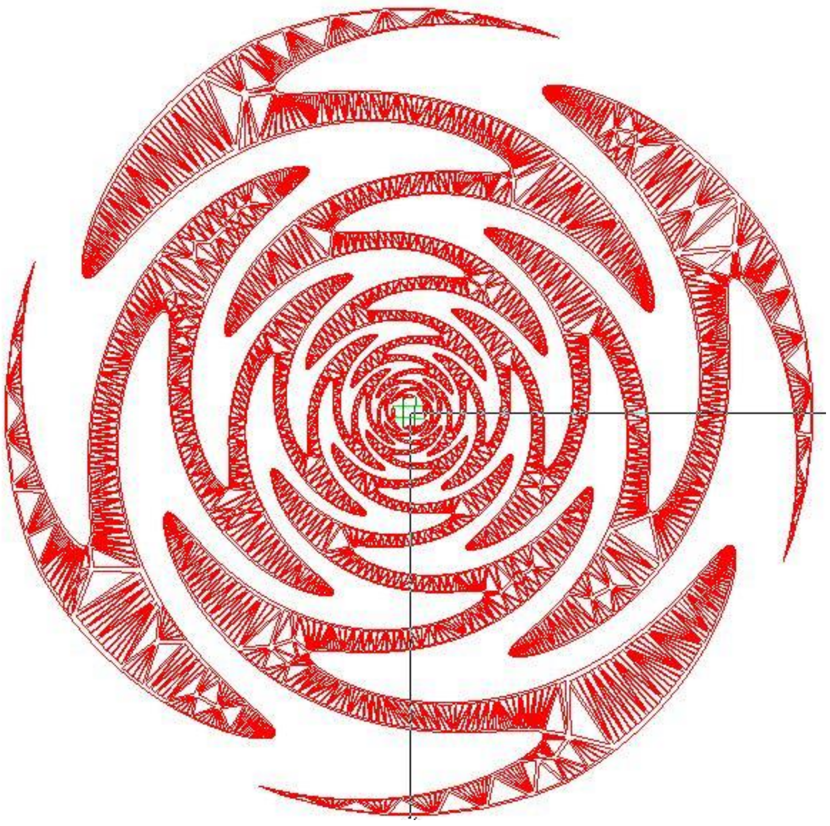
Sinuous antenna (voltage source excitation)

- The two-excitation ports with voltage sources type connected to the four arms of the sinuous antenna at the center of the antenna.

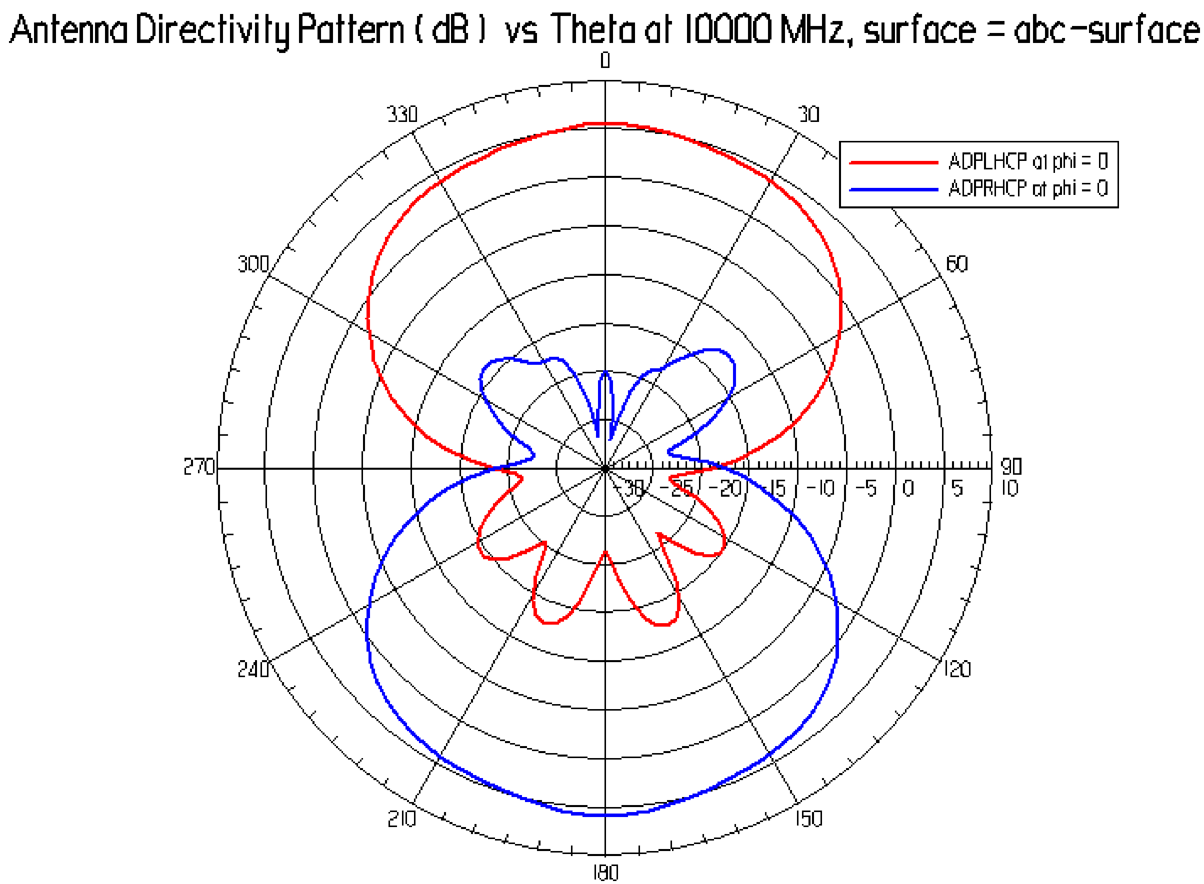


Sinuous antenna (Meshing)

- Meshing of sinuous antenna at 10GHz generated by Ansoft HFSS.

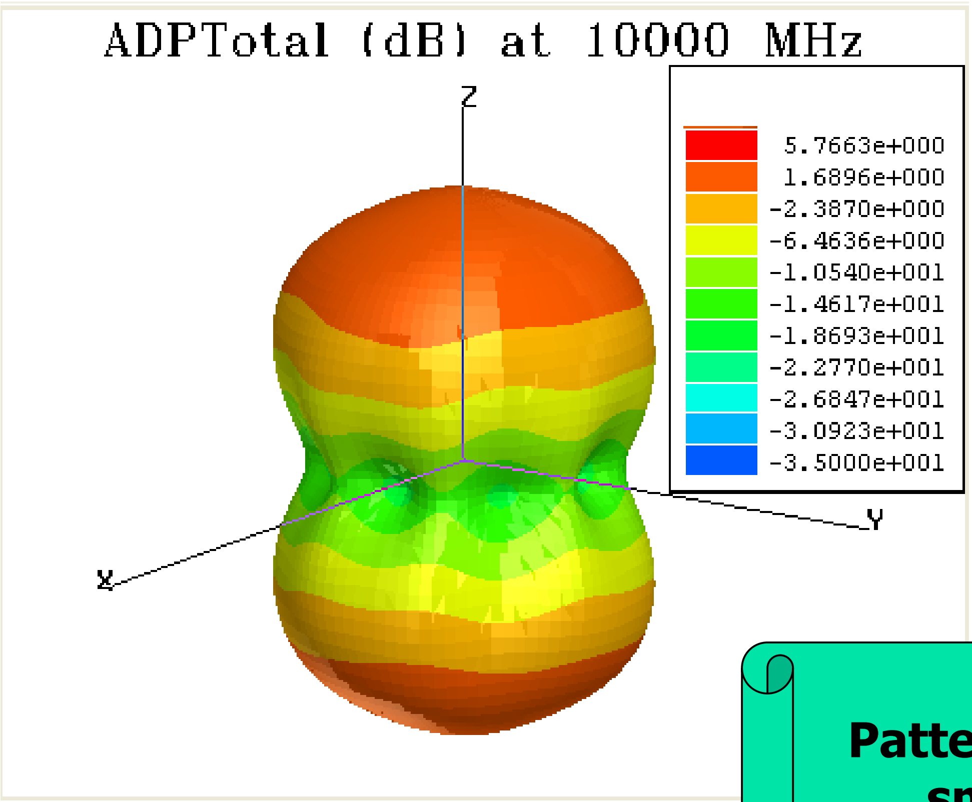


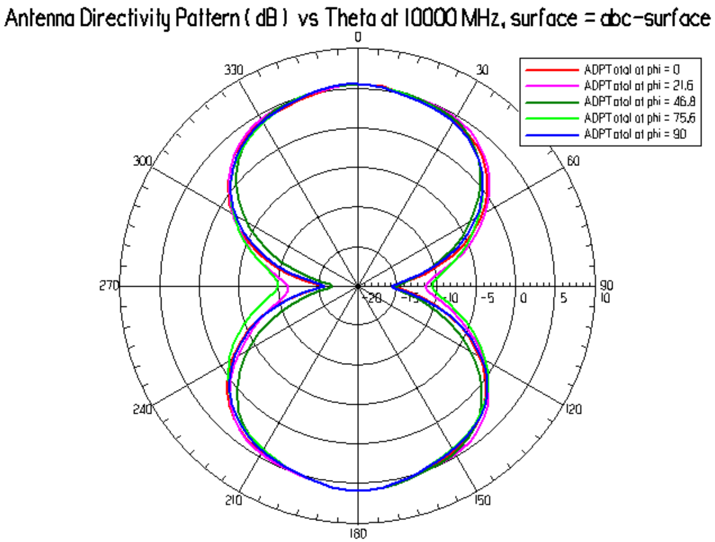
Sinuous antenna (Simulation results)



- 2 arms of sinuous antenna are excited with 90° phase Difference to reach both RHCP and LHCP, simultaneously.

Sinuous antenna (Simulation results)

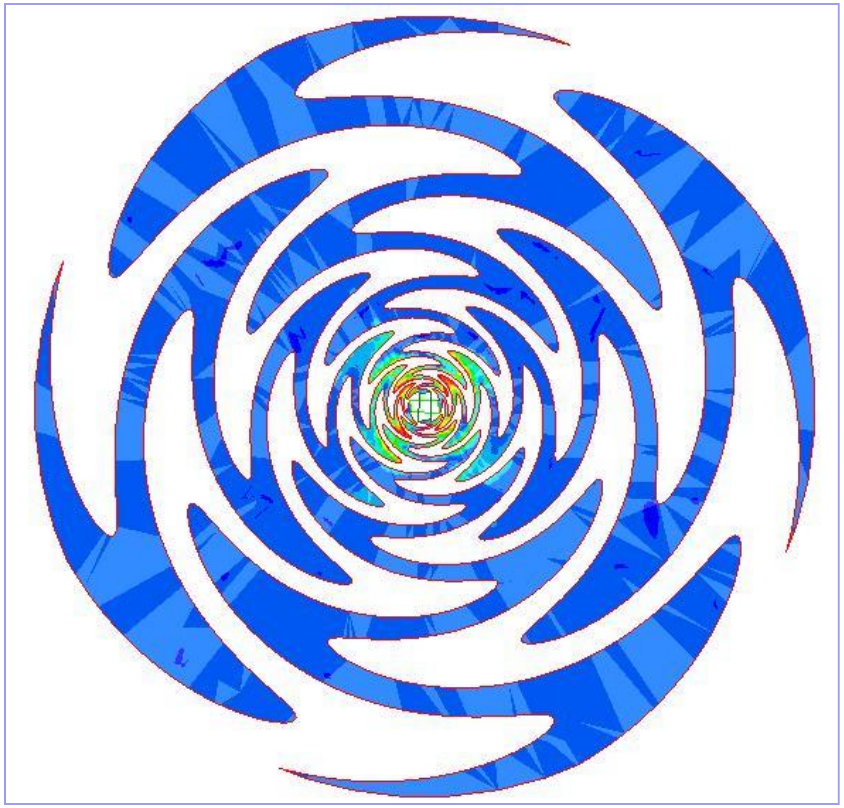




Pattern cuts show very smooth radiation characteristics

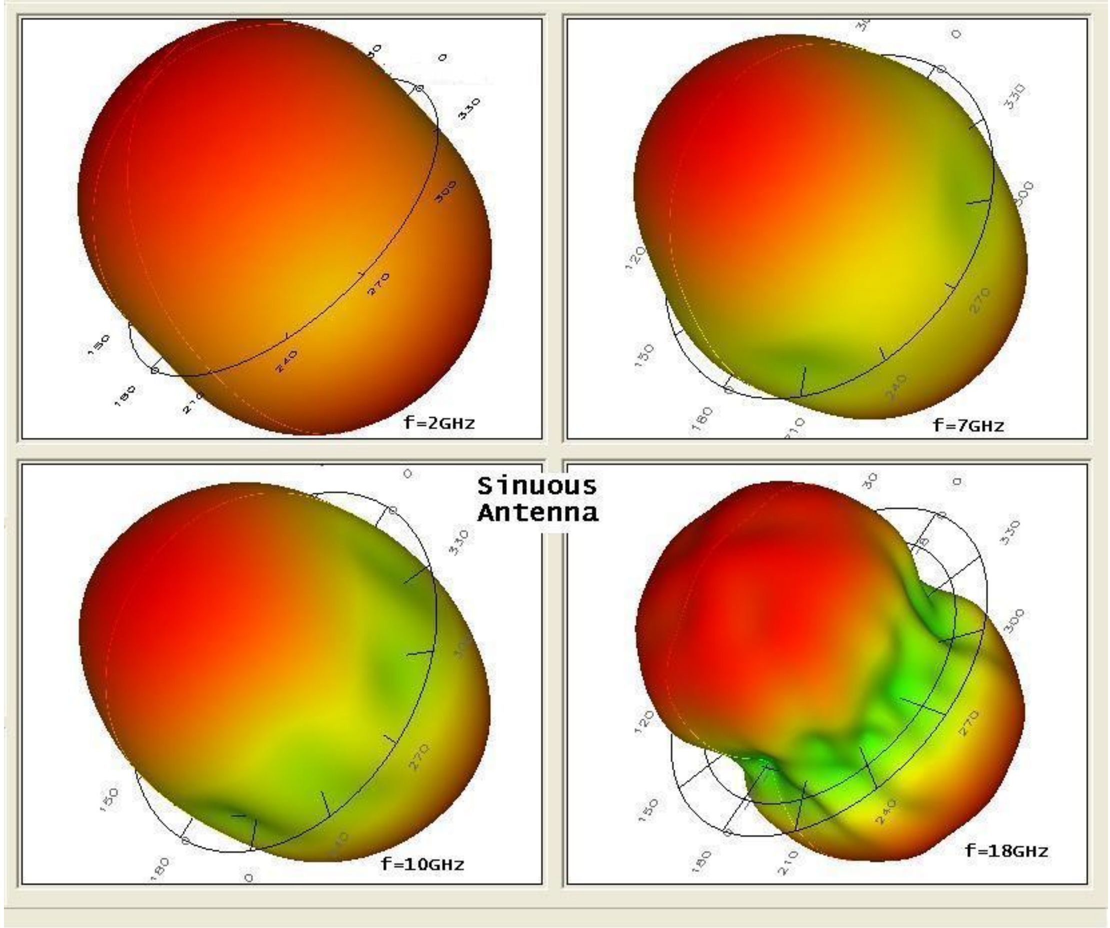
Sinuous antenna (Simulation results)

- Current distributions over the sinuous antenna aperture at 10GHz. Two arms are excited with 90° phase difference.



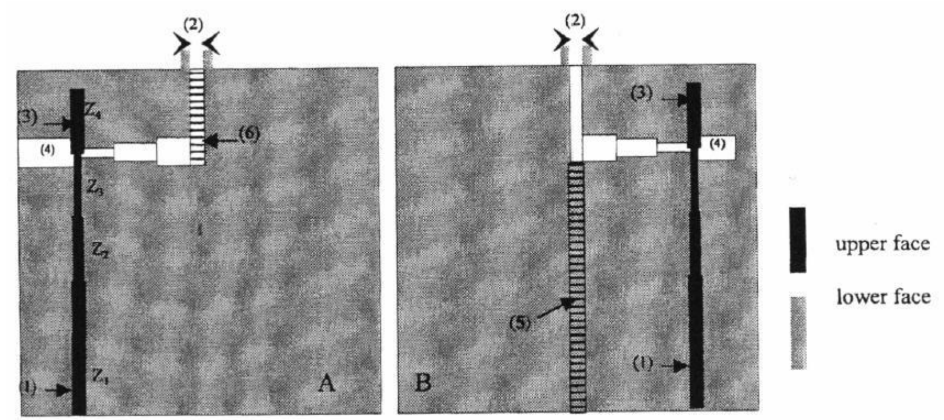
Sinuous antenna (Simulation results)

- 3D Radiation Pattern of Sinuous antenna in some different frequencies.

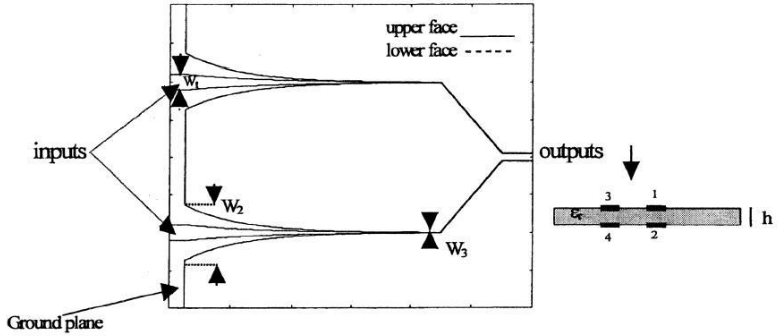


Sinuous antenna (feeding circuits)

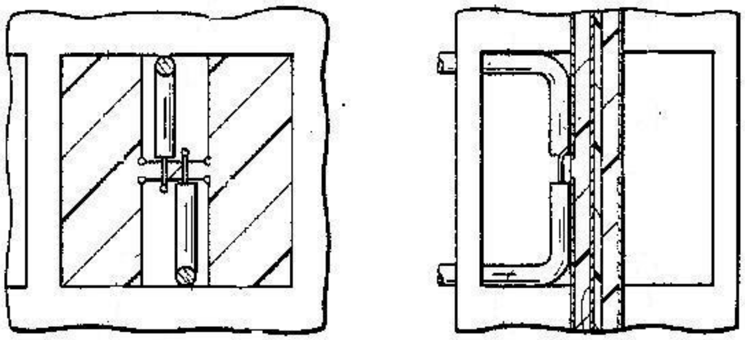
- Sinuous antennas can be developed using a variety of circuit elements.



Microstrip/Slotline Balun.



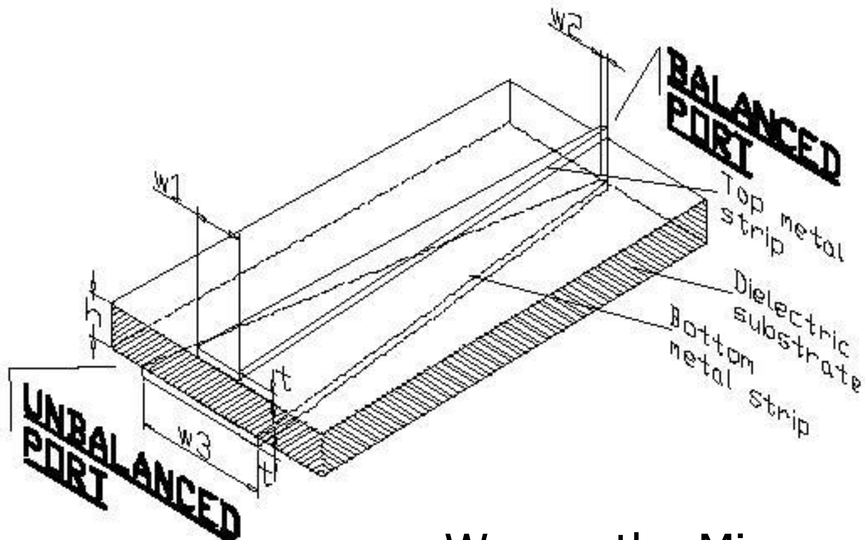
Microstrip Tapered Line Balun

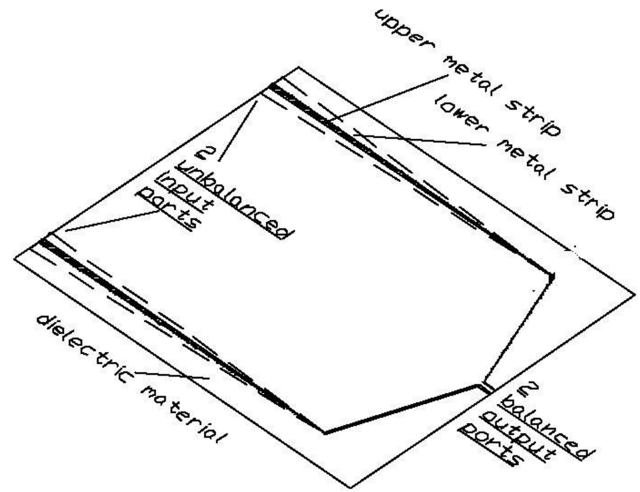


Marchand Balun

Sinuous antenna (Microstrip Tapered Balun)

- Microstrip Tapered Balun Configuration

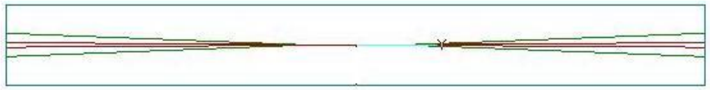


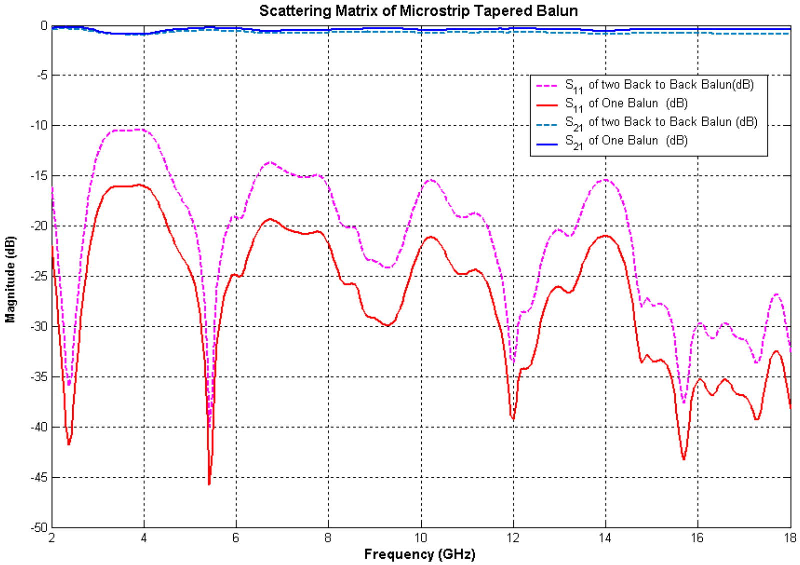


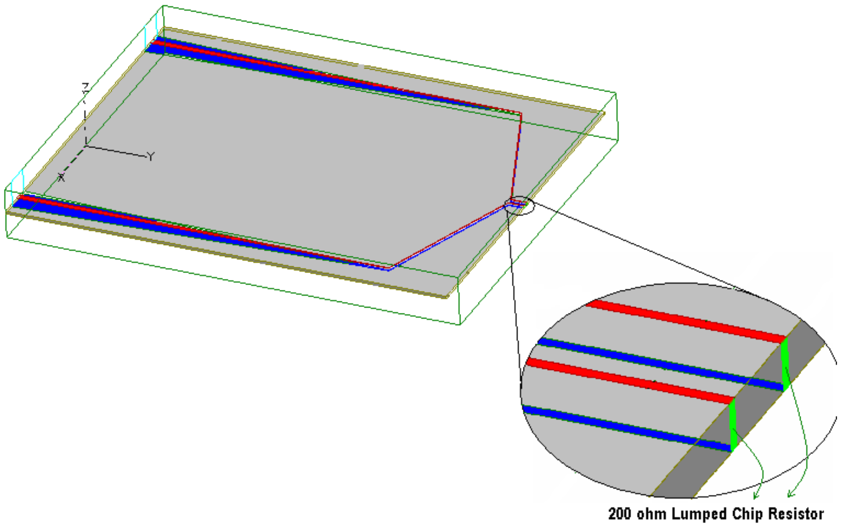
We use the Microwave Office Tx line Calculator to find these values by using the dimensions of the line.
Substrate : RO4003 Er = 3.38 , h = 20 mil
W1 = 46 mil, W3 = 5 x W1 = 125 mil
W2 = 5 mil

Sinuous antenna (Microstrip Tapered Balun)

That Balun simulated by Ansoft HFSS in 2-18 GHz .

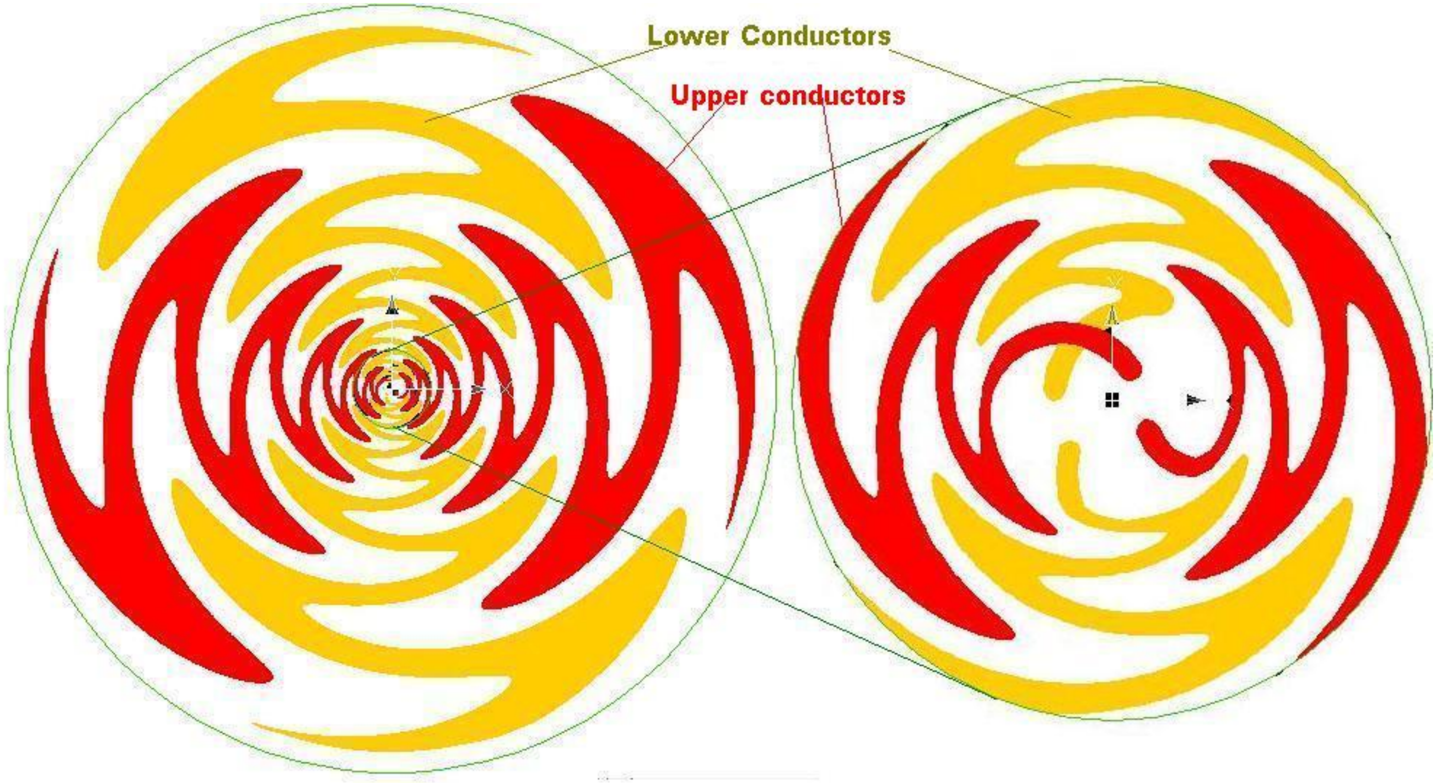






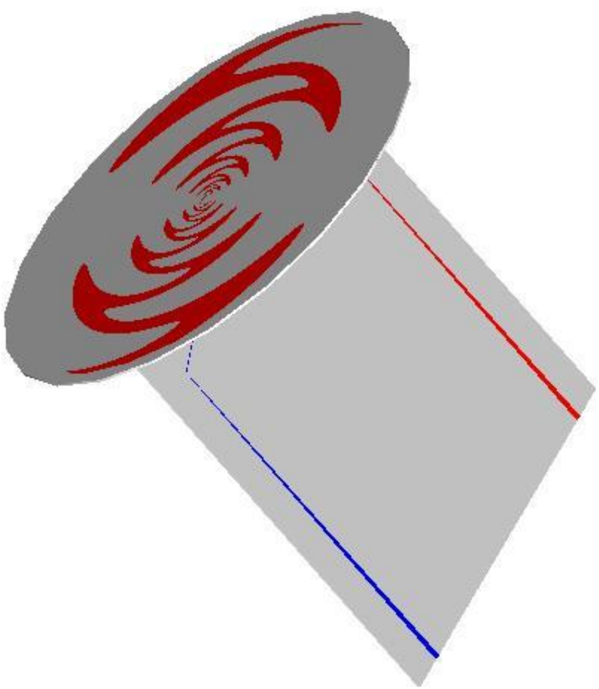
Sinuous antenna (Microstrip Tapered Balun)

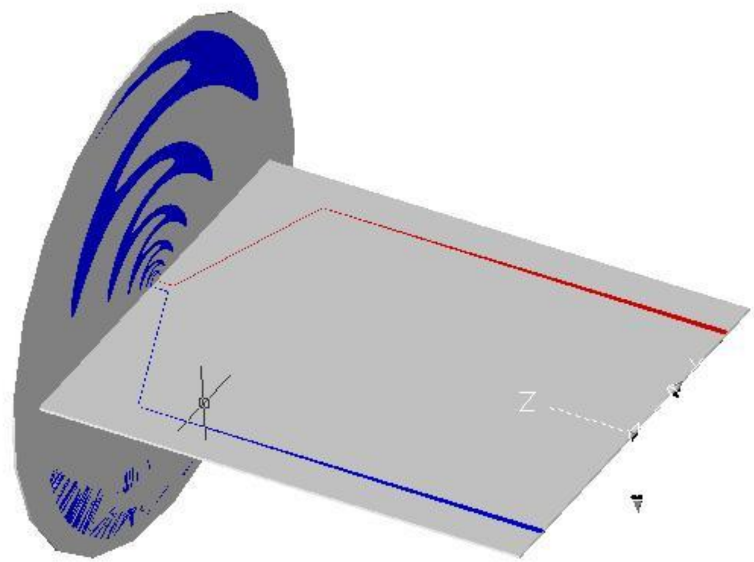
- The PCB (Printed Circuit Board) antenna card is designed as two sided for integration with Tapered baluns.



Sinuous antenna (Microstrip Tapered Balun)

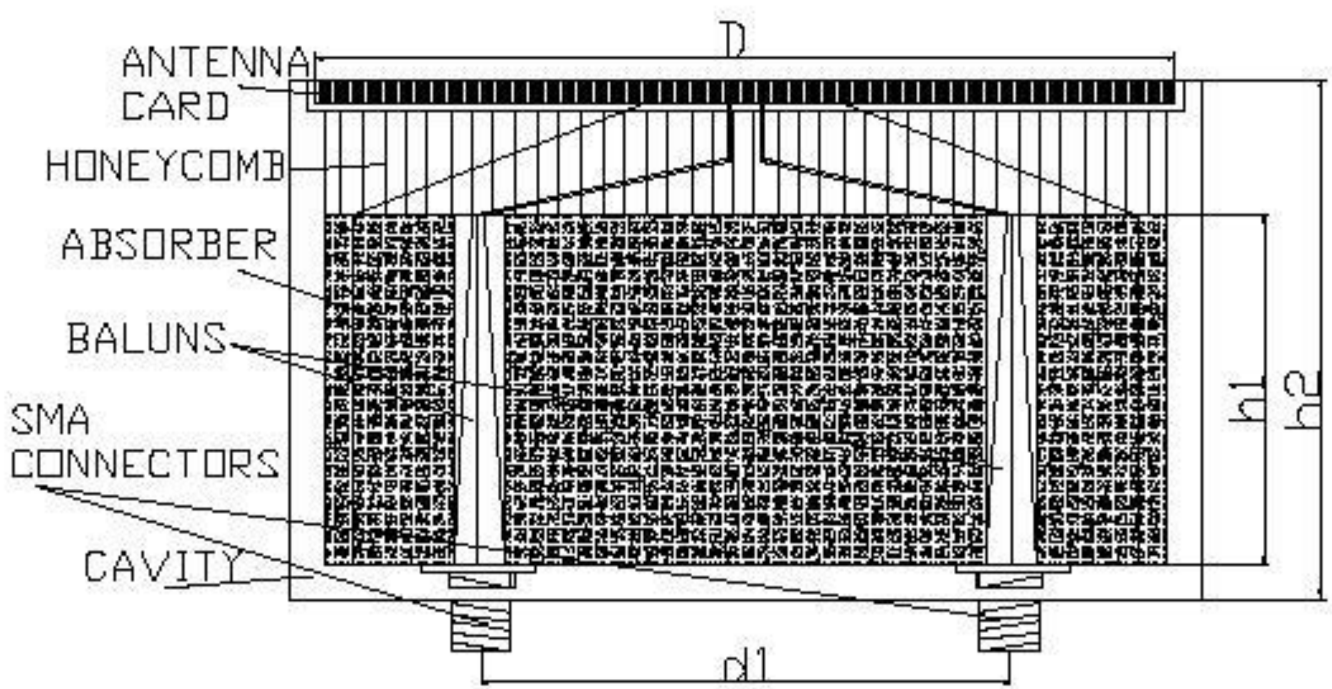
- Up and Bottom sides of sinuous antenna with Tapered balun connections.



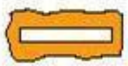
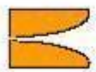
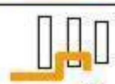
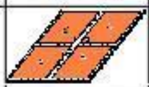


Sinuous antenna (Cavity Design)

- The planar Sinuous antennas have bi-directional radiation. By positioning them inside a cavity that filled by absorber material, they become uni-direction.



Planar antenna selection chart.

		Pattern	*Directivity*	*Polarization*	*Bandwidth*	*Comments*
Patch		Broadside	Medium	Linear/Circular	Narrow	Easiest design
Slot		Broadside	Low/Medium	Linear	Medium	Bi-directional
Ring		Broadside	Medium	Linear/Circular	Narrow	Feeding complicated
Leaky-Wave		Scannable	High	Linear	Medium	Beam-steering, Beam-tilting
Bow-Tie		Broadside	Medium	Linear	Wide	Same as Spiral
TSA(Vivaldi)		Endfire	Medium/High	Linear	Wide	Feed transition
Yagi Slot		Endfire	Medium	Linear	Medium	Two layer design
Quasi Yagi		Endfire	Medium/High	Linear	Wide	Uniplanar, Compact
Four Squre		Broadside	Medium	***Dual linear***	Medium	Balun
Spiral		Broadside	Medium	Circular	Wide	Balun & Absorber
Sinuous		Broadside	Medium	***Dual linear***	Wide	Balun & Absorber
Log periodic		Broadside	Medium	***Dual linear***	Wide	*Integrated Balun & Absorber*

With Thanks !