"Vivaldi Antenna for UWB Communications"

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BY

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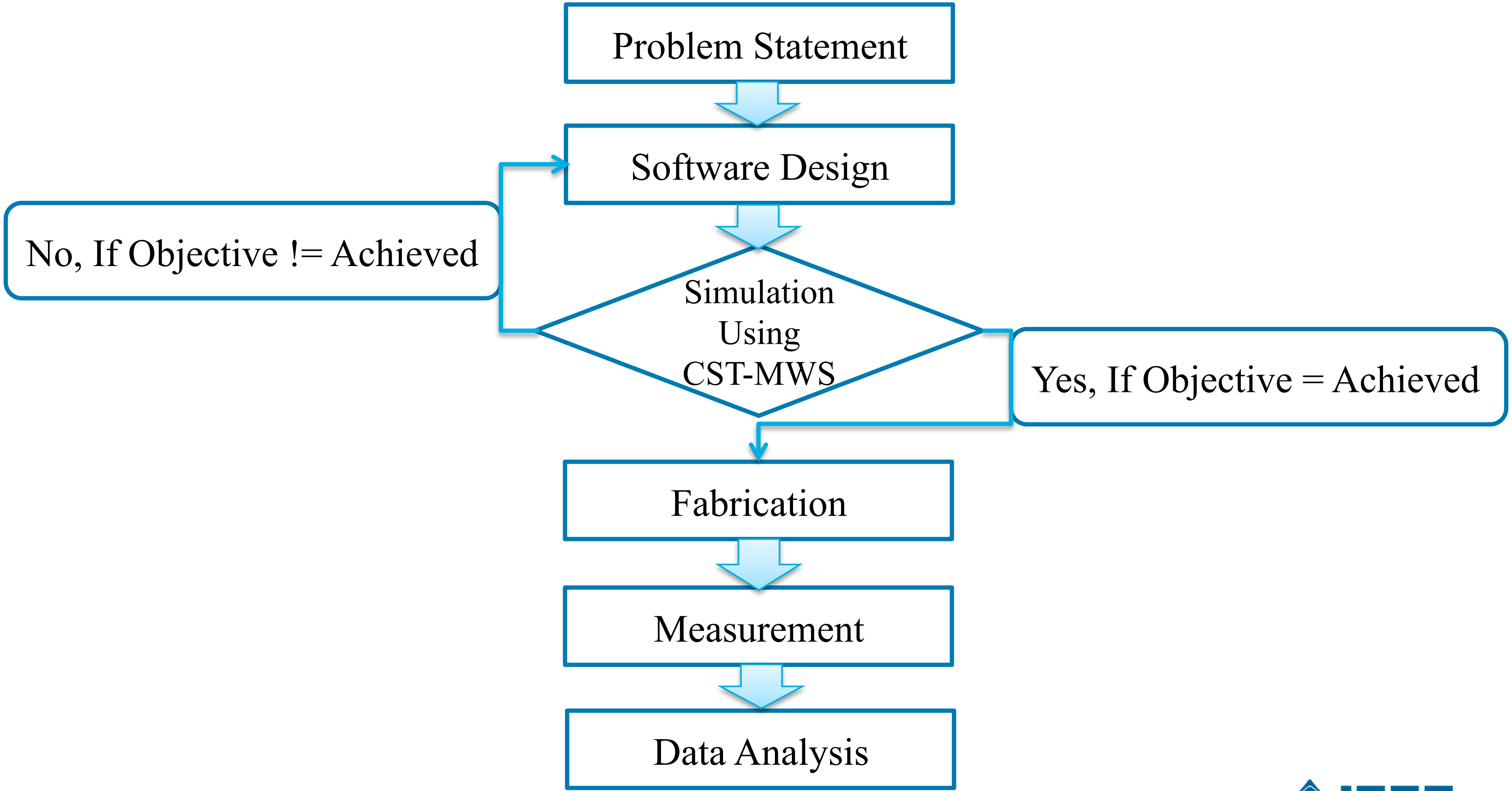
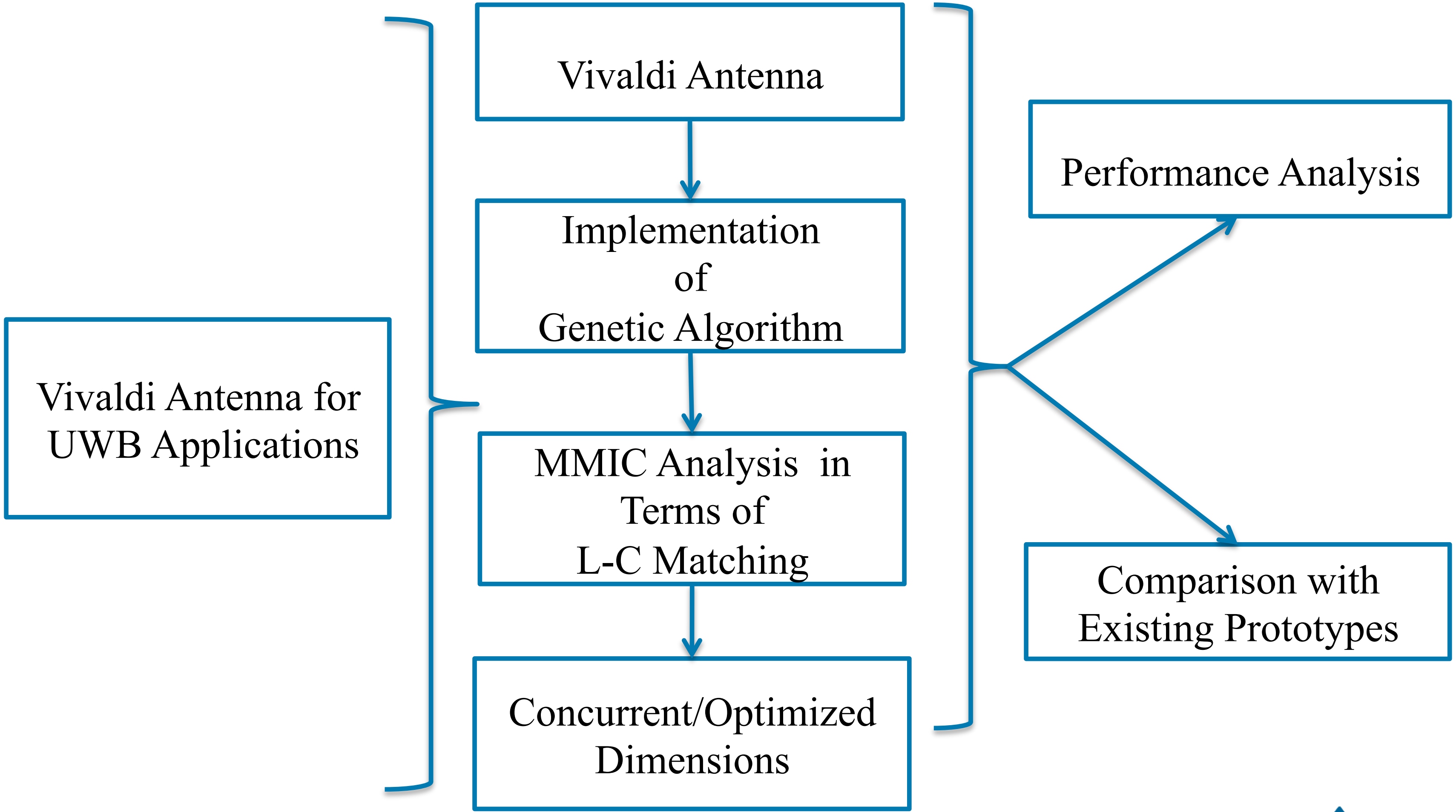
OUTLINE OF THE PRESENTATION

- Roadmap
- Objective
- Introduction
- Antenna Design
- Results, Discussion and Analysis
- Appendices
- Conclusion
- References

ROADMAP


Problem Statement
Software Design
No, If Objective != Achieved
Simulation Using CST-MWS
Yes, If Objective = Achieved
Fabrication
Measurement
Data Analysis

OBJECTIVE


Vivaldi Antenna for UWB Applications
Vivaldi Antenna
Implementation of Genetic Algorithm
MMIC Analysis in Terms of L-C Matching
Concurrent/Optimized Dimensions
Performance Analysis
Comparison with Existing Prototypes

INTRODUCTION

- Since Federal Communications Commission's choice of allowed the unlicensed operation from 3.1 GHz to 10.6 GHz in 2002, UWB has been progressively developed from the academics to the industry fields.

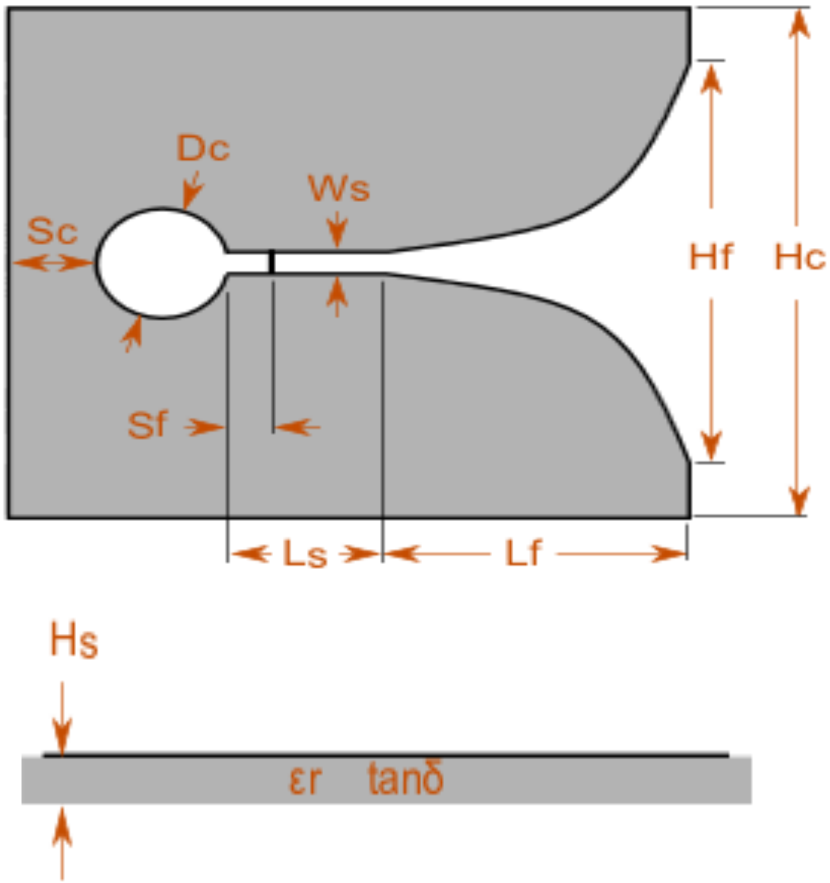
- A UWB antenna should be designed with the characteristics of: small size, good impedance matching, minimum group delay and omnidirectional radiation pattern.

- In the recent years, Vivaldi antennas have received quite vast attention due to wide bandwidth characteristics. It belongs to the class of a periodic & continuously scaled antenna structures with exponentially tapered curve with significant flatness of gain.

- They are widely used in UWB applications: ground penetration radar, satellite communication, medical treatment and vehicular wireless communication.

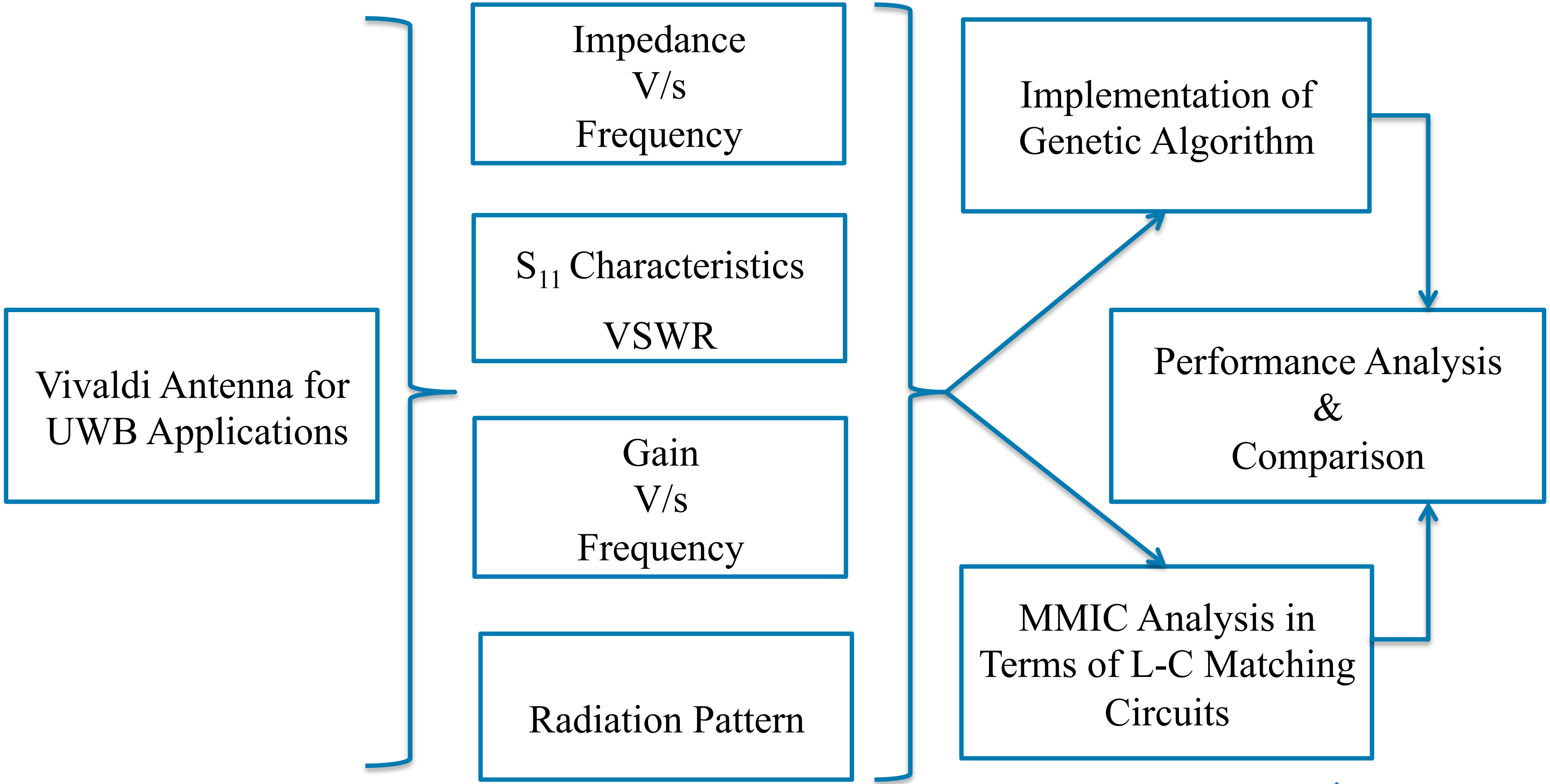
- Therefore, it can be concluded that Vivaldi Antenna is a good candidate for UWB as:
  1. Wide Impedance Bandwidth.
  2. Stable Radiation Pattern.
  3. High Gain Characteristics.

ANTENNA DESIGN

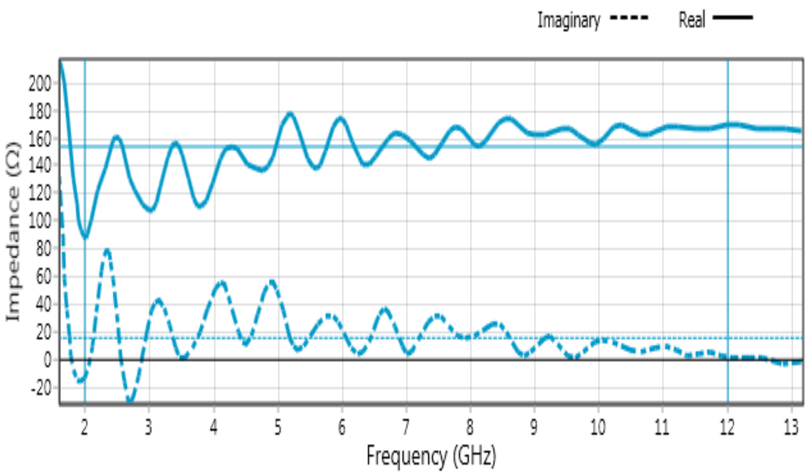


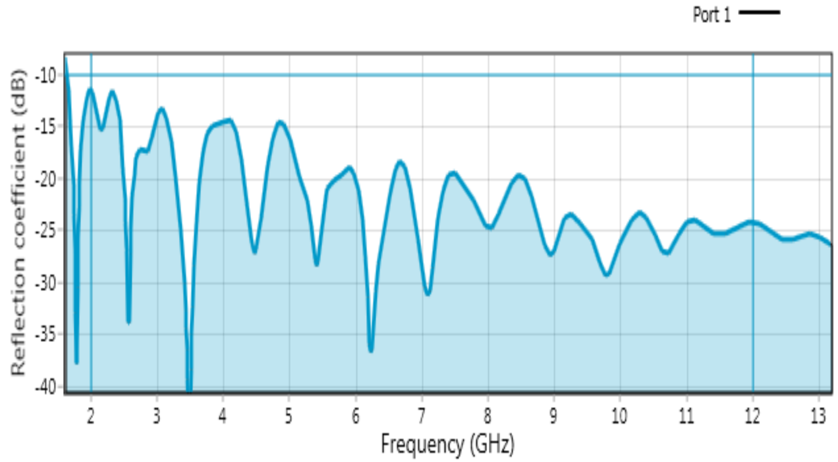
Parameters	Dimensions
Flare Height, *Hf*	82.44 mm
Flare Length, *Lf*	157.4 mm
Height of Conductor, *Hc*	104.9 mm
Width of Slotline, *Ws*	1 mm
Cavity Diameter, *Dc*	29.98 mm
Distance from Back Wall to Cavity, *Sc*	29.98 mm
Distance from Cavity to Feed, *Sf*	1.5 mm
Length of Slotline, *Ls*	3 mm
Substrate	Rogers 5870
Relative Permittivity	2.33

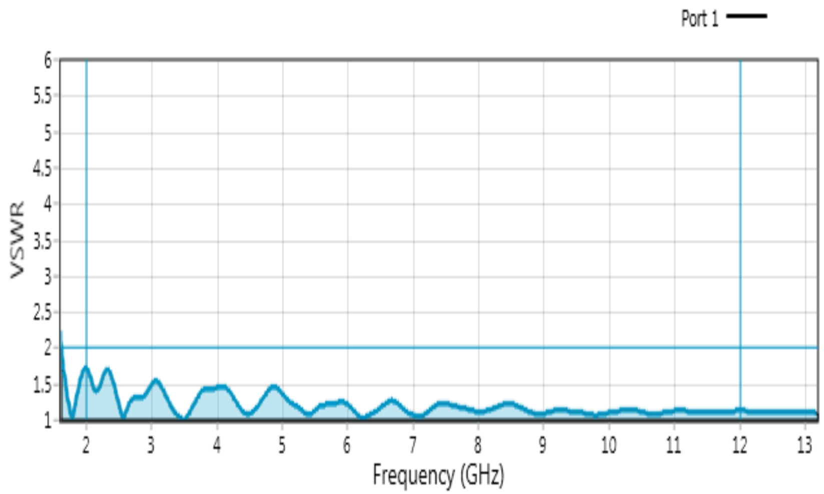
RESULTS, DISCUSSION AND ANALYSIS



EXPLORATION OF OUTCOMES

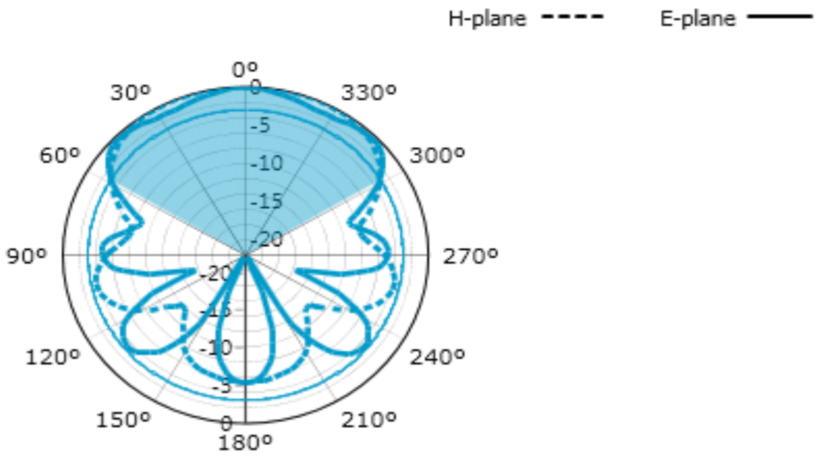


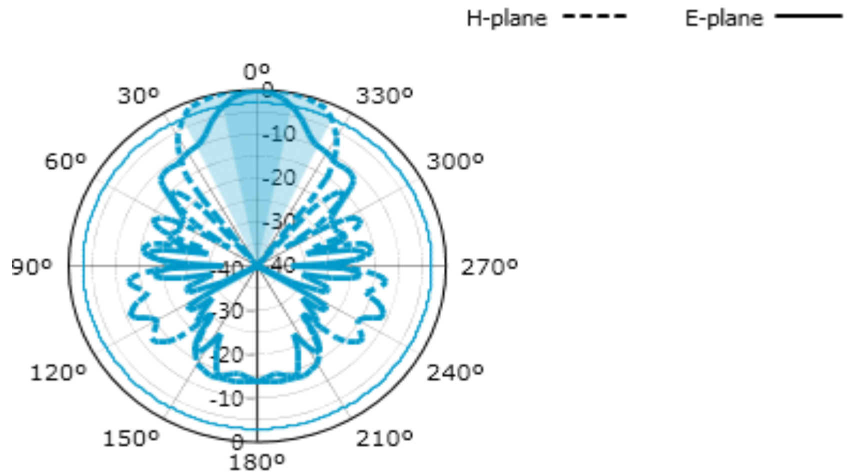


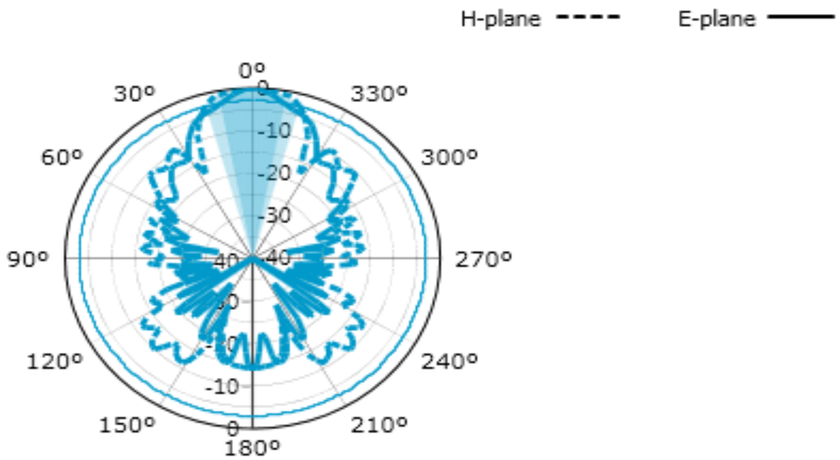


- Impedance V/s Frequency Plot (*Top Left*).
- S_{11} Characteristics Plot (*Top Right*).
- VSWR Characteristics Plot (*Bottom Left*).
- Covers entirely 2-12 GHz, with an -10 dB Impedance Bandwidth of 10 GHz & UWB from 3.1-10.6 GHz where $S_{11} < -10$ dB.
- VSWR < 2.

EXPLORATION OF OUTCOMES-I

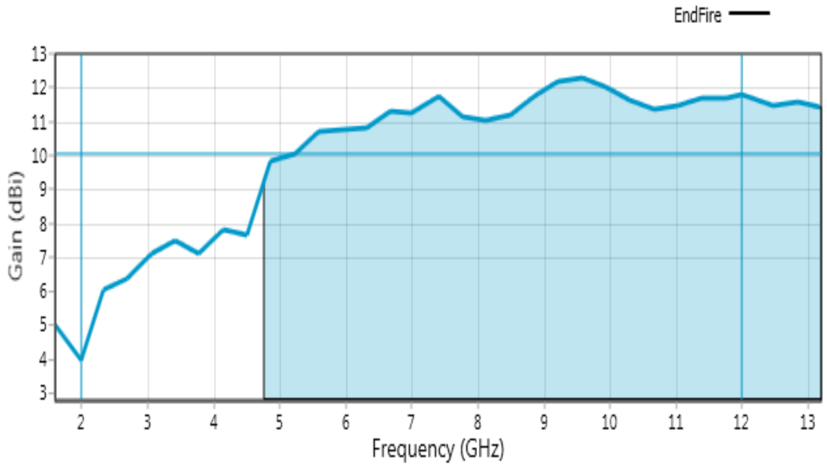




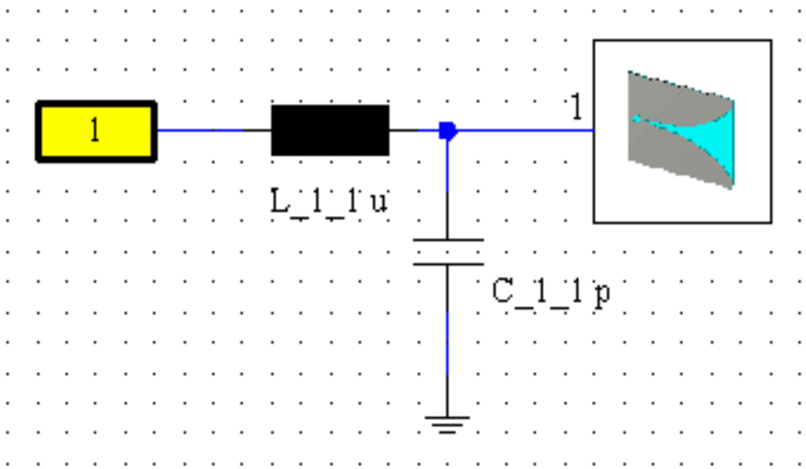


- Radiation Pattern at 2 GHz (*Top-Left*).
- Radiation Pattern at 7 GHz (*Bottom-Left*).
- Radiation Pattern at 12 GHz (*Top-Right*).
- It has an End-Fire Radiation Pattern.
- Symmetric Beam is observed in E-Plane and H-Plane over the wideband, provided all the dimensions are calculated properly.

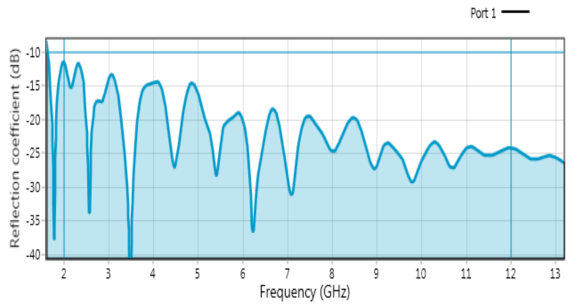
EXPLORATION OF OUTCOMES-II



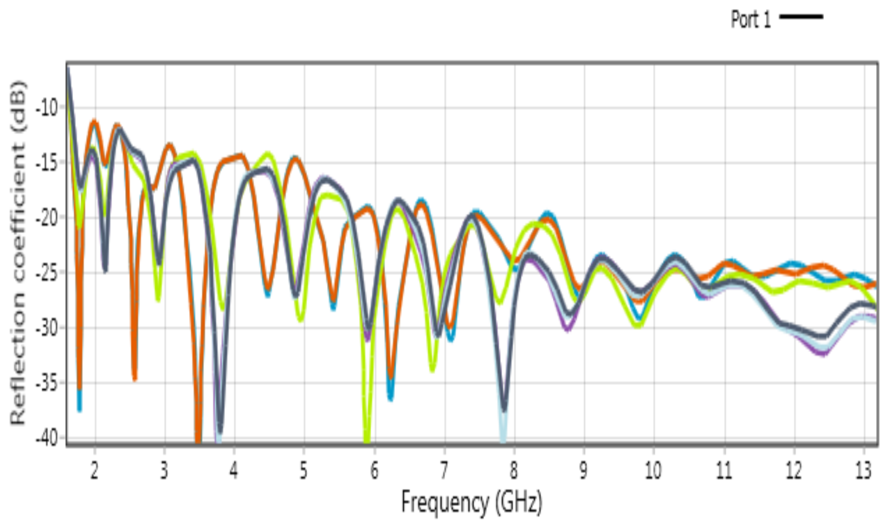
- Highest Gain of 12.27 dBi at 9.5 GHz.
- Consistent Gain of above 10 dBi from 5-13 GHz is observed.
- These facts makes the Vivaldi Antenna, a good antenna for UWB Applications.



- MMIC Analysis in terms of L-C Matching.
- L=0.49 nH and C=0.306 pF at 50 Ω.



EXPLORATION OF OUTCOMES-III



Parameters	Optimum Range	Used Here
Population Range	30-100	55
Probability of Crossover	0.6-0.9	0.8
Probability of Mutation	0.01-0.1	0.06
Replacement Strategy	Steady State	Steady State

- Genetic Algorithm (GA) describes the effect of the constructional parameters on a overall behaviour and it helps to extract out the best possible combinations in a optimized way.

- Important concepts in GA:
  - ✓ Population (*Set of Trials*)
  - ✓ Parent (*Member of Current Generation*)
  - ✓ Child (*Member of Next Generation*)
  - ✓ Generation (*GA iterations / Successively Created populations*)
  - ✓ Chromosome (*Coded Form of Trial Sol. Vector/String Consisting of Genes/Alles*)
  - ✓ Fitness (*Positive Numbers Assigned to Individual, Representing a Measure of Goodness*)

EXPLORATION OF OUTCOMES-III <CONTINUED>

- Why Genetic Algorithm* is chosen over others?
  - ✓Operates → *group*/*population* of trial solutions in parallel.
  - ✓Operates on → coding of function *parameters*/*chromosomes* rather than individual parameters themselves.
  - ✓Uses out → simple, stochastic case (*selection*, *crossover* & *mutation*) as operators to explore solution domain.

* J.M.Johnson and Y.Rahmat-Samii, "Genetic algorithm in engineering electromagnetics", *IEEE Antennas and Propa-- gation Magazine*, Vol. 39, No. 4, 1997, pp. 7-21.

- Certain Guidelines to be followed while implementing on Genetic Algorithm*:
  - ✓Population Size: 30-100
  - ✓Probability of Crossover: 0.6-0.9
  - ✓Probability of Mutation: 0.01-0.1
  - ✓Replacement Strategy: Steady State

- Additional Effects:
  - ✓Large Populations leads to more Genetic Diversity and scopes Faster Convergence.
  - ✓High Crossover Probability leads to Faster Searching.
  - ✓Low Mutation Value makes the Average Fitness far from Optimal Values.

EXPLORATION OF OUTCOMES-IV

Parameters	[8]	[9]	[10]	Proposed Antenna
Bandwidth Range	3-11 GHz	3.1-10.6 GHz	2 GHz	2-12 GHz
Gain	7.8 dBi	~7.2 dBi	5.9 dBi	12.27 dBi
Resonating Frequencies	S, C and few X-Bands	S and C-Bands	C-Band	S, C and X-Bands

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APPENDICES-I

Constructional Parameters	Dimensions in mm
Flare Height, *Hf*	65.95-**82.44**-98.93
Flare Length, *Lf*	110.2-**157.6-**204.6
Height of Conductor, *Hc*	**104.9**-125.9
Width of Slotline, *Ws*	**1**-1.5
Cavity Diameter, *Dc*	14.99-**29.98**-44.97
Distance from Back Wall to Cavity, *Sc*	14.99-**29.98**-44.97
Distance from Cavity to Feed, *Sf*	**1.5**

"Bold counter parts presents the Dimensions used to design proposed antenna, while Genetic Algorithm is implemented for calculating the Optimized Dimensions in case of Vivaldi Antenna for UWB Applications"

APPENDICES-II

- In order to design Vivaldi Antenna, certain guidelines must be followed as:

  ✓ Flare Height should be greater or equal to a half-wavelength at minimum operating frequency.

  ✓ Flare Length should be greater than or equal to a wavelength at minimum operating frequency.

  ✓ Beamwidth decreases & directivity increases as Flare Length is increased.

  ✓ To decrease (increase) input impedance, decrease (increase) the Slotline Width.

  ✓ Taper factor influences impedance match and beamwidth.

  ✓ Cavity diameter should be equal to 0.2λ at minimum operating frequency.

"Flare Height, Flare Length, Slotline Width, Taper Factor, Cavity Diameter"

CONCLUSION AND FUTURE SCOPE

- Relevance's drawn from the proposed antenna: Bandwidth Range of 2-12 GHz and Gain of 12.27 dBi at highest level.
- It produces operational frequencies : 0-3 GHz for Medical Applications, 2-4 GHz for S-Bands, 4-8 GHz for C-Bands and 8-12 GHz for the X-Band Applications.
- Implementation of Genetic Algorithm lead to extraction of correct approach for enhancing the capability of proposed antenna and to do the parametric variation.
- L-C Matching was carried out to witness its stance for real time scenarios or implications.
- Thus it created a base where these approaches can be made for the Wireless Communication Systems especially for Antenna's.

Future Expansion

- In future, Metamaterials are to be incorporated in order to increase all the major functionalities to a certain level i.e. to achieve Band-Notching characteristics.

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This presentation was prepared for 2016 2nd IEEE International Conference on Control Computing Communication and Materials (ICCCCM-2016) held at Allahabad, Uttar Pradesh, India on October 21-22, 2016.

My research interest includes EBG Structures, Printed Antenna, Metamaterials, Circuit Analysis, Genetic Algorithm & UWB Antennas. I had authored in 2 Journals (SCI-Indexed) and 2 Journals (Thomson Reuters) & holds on IEEE Conference publications/ acceptance of 19 articles at the time of pursuing Masters (2016) and working as Associate (2017). I am associated with IEEE-Associate Member in Antenna and Propagation Society, Communication Society and Networking Consultant.

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