Antenna Design for Ultra Wideband Communication

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Contents

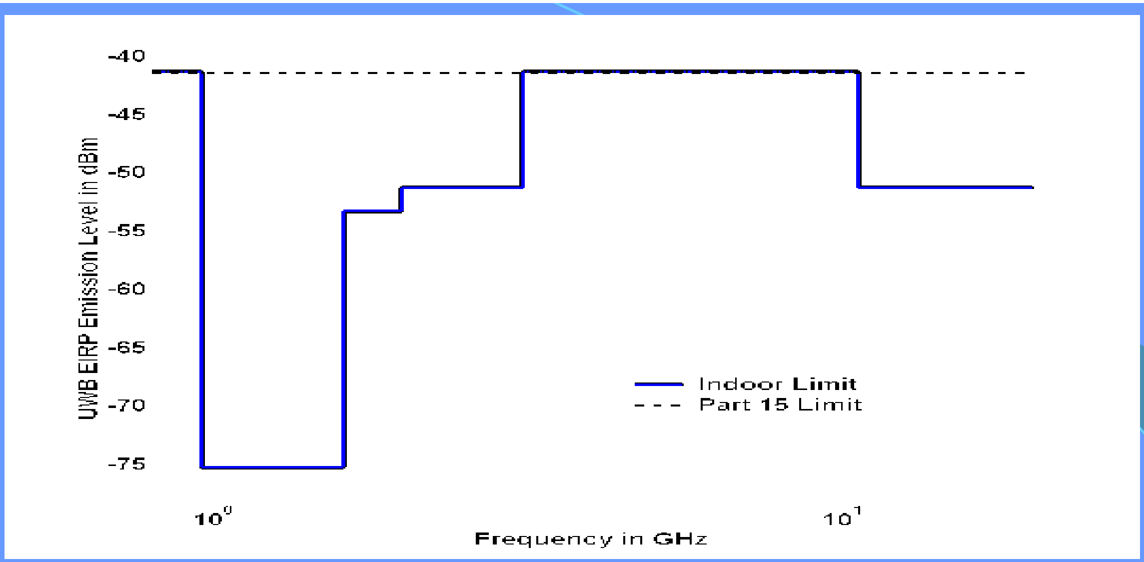
Introduction

- **UWB Technology**

- A wireless digital technology that can transmit a large amount of data with a minimum power.
- Wireless technology began as UWB before 1900.
- Early 1960`s ,with the dev`t of sampling osilosscope, UWB came back again.

- In 2002 UWB approved by FCC for commercialization.
  - UWB Fractional Bandwidth > 20% meaured at –10 dB point.
  - Systmes having total bandwidth of 500 MHz.
  - Very low power spectral density (PSD)

Introduction



- **Approved Spectrum by FCC is application Specific**
- Communication, medical Imaging, and measurement System:

  3.1 to 10.6 GHz
- Ground penetrating radars and wall imaging : < 960 MHz, and 3.1 to 10.6 GHz
- Thru-wall Imaging and serveillance system : 1.99 to 10.6 GHz
- Vehicular radar Systems: 22 to 29 GHz

Introduction

➢ Advatages of UWB

- High Data rate

  Shannon Theory ,

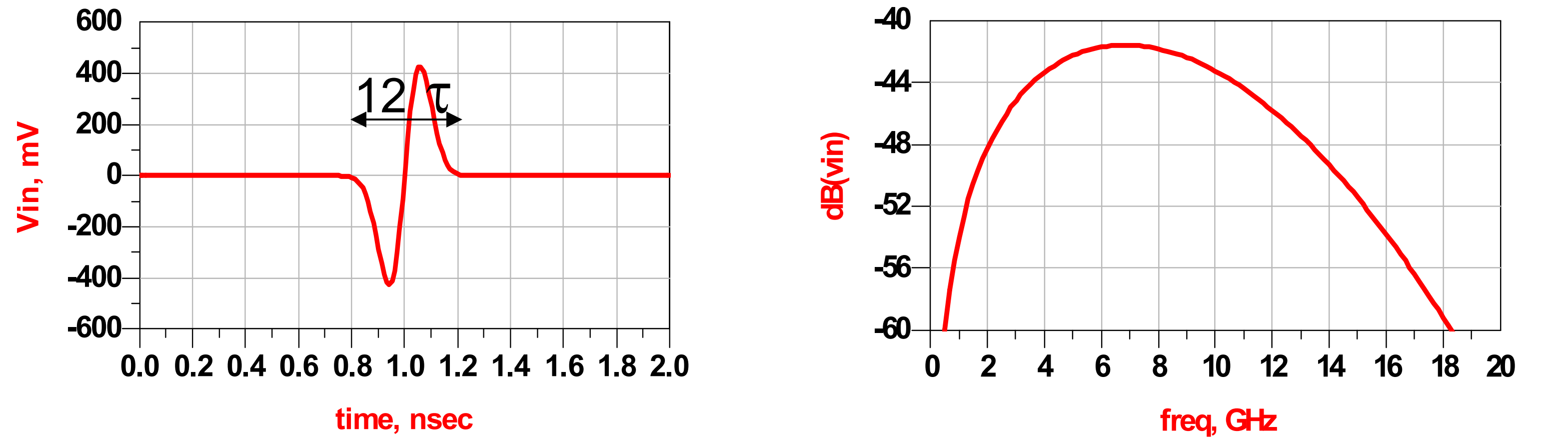
  $C = B\log_2(1 + S/N)$

- Its implementation is fairly cost effective

- Low power

- It can share frequncies that are already occupied by other communication facilities.

- **Gaussian monocycle**



f_c is proportinal to the inverse of τ. Thus for τ = 0.033 nsec, f_c = 6.85 GHz and its bandwidth equals 7.5 GHz

Introduction

➤ **Advantage of gaussian monocycle**

- Its spectrum does not contain low-frequency components including dc.
- It is commonly employed in UWB systems due to its simpler realization.

Introduction

➢ UWB Antenna Design Challenge

- UWB Antenna need to have
  - Proper Returnloss
  - linear phase
  - Constant radiation pattern, in the frequncy band of operation.
- In addtion, if the antenna is intended to be used for mobile UWB Communication application , the antenna should satisfy:
  - Light weight, planar structure, and Omni directional radiation pattern.

Objective

- To adopt different broadband planar antennas from literature and simulate the characteristics of these antennas using the 3D-EM simulation software (HFSS).
- To create a model for the antennas based on the data (S-parameters and radiation pattern), for the circuit simulation software Agilent ADS.
- To investigate the response of the antennas (the created model) on excitation with transient pulses and, hence, to test the efficiency of the antennas for mobile UWB communication applications.

Antenna Design and Model

➢ Selected antennas

- Double sided printed Bow-tie antenna(DSPBT)
- Balanced antipodal vivaldi antenna(BAV)
- New planar UWB antenna

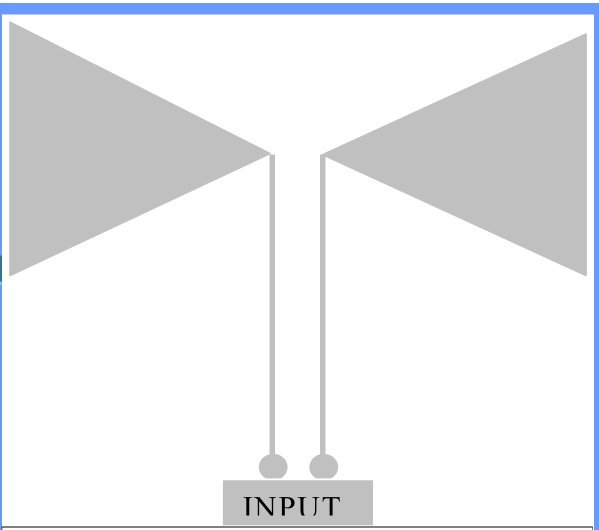
➢ Antenna Simulation

- The simulation was done with HFSS
- S-parameter and far field data were generated

Antenna Design and Model

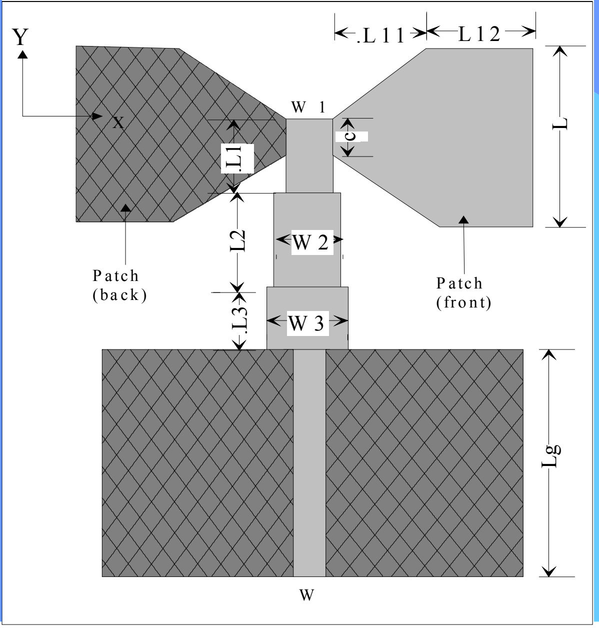
Bow-tie

Antenna



➤ Bow-Tie Antenna

- ➤Bow-tie antenna is known for its geometry simplicity
- Since the bandwidth of the conventional Bow-tie antenna is not sufficient for the application of UWB , Modification has been done.
- Double Sided Printed Bow Tie antenna consists of two patches printed on top and bottom side of a dielectric substrate.
- Size in mm(36·36·1.27)

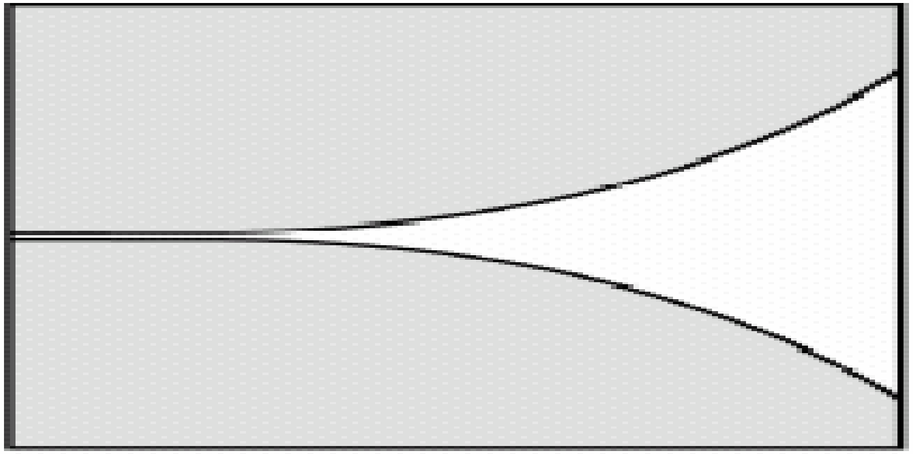


DSPBT

Antenna

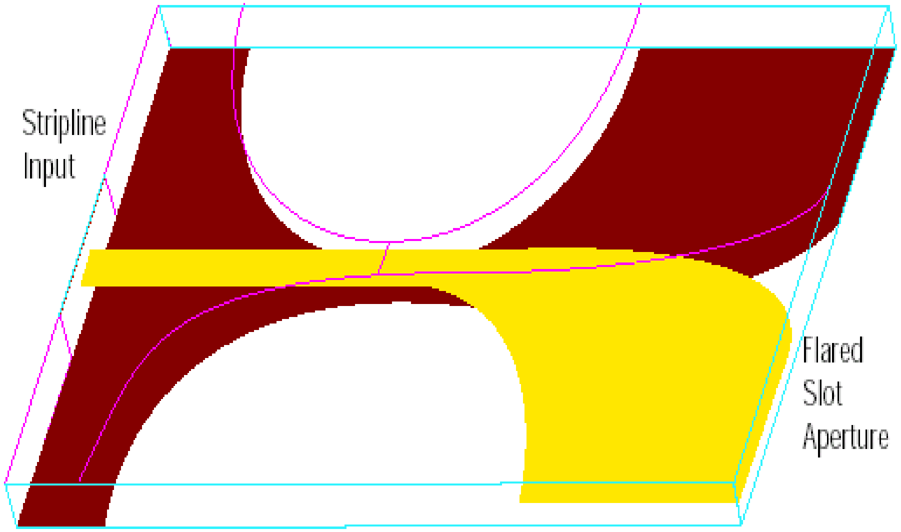
Antenna Design and Model

Vivaldi Antenna



Vivaldi Antenna

- Vivalde antenna is a special type of tapered slot antenna (TSA) with exponential flare profile.
- The Bav antenna starts in a stripline. One side of the board has the input track that is then flared to produce one half of a conventional vivaldi. On the other side, the ground planes are reduced to a balanced set of lines that are flared-out in the opposite direction to form the overall balanced structure.
- Size in mm(90·40·3.15)



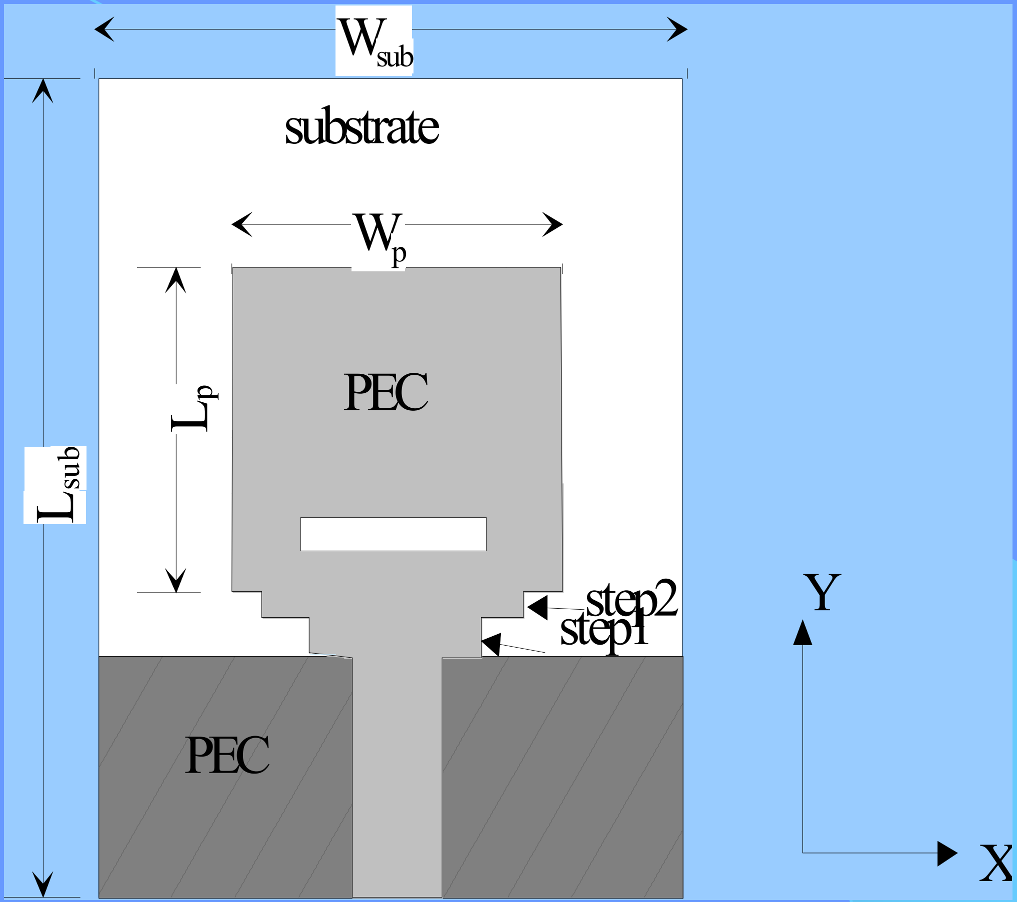
BAV Antenna

Monopole Antenna

- Monopole antennas are known for their omnidirectional radiation pattern in azimuthal plane. However, the usal monople antenna is perpendicular to its ground plane.

- Printed planar monopole antennas overcome these shortcomings.

- Size in mm(35·30·1.6)



NPUWB Antenna

New Planar UWB Antenna

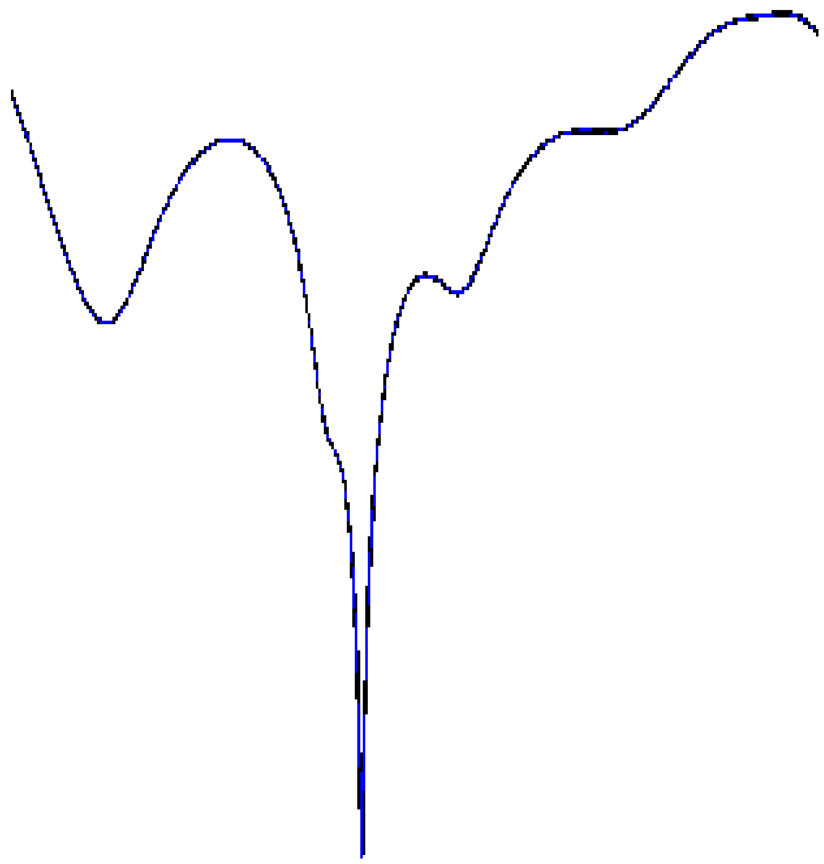
- A well known way to overcome the previously mentioned shortcomings, is by making the already existing ground plane an active part of the radiating system.

- This is the fundamental principle of the category of printed monopole antennas that use the ground plane through current induction to produce an asymmetric image of the monopole.

Results

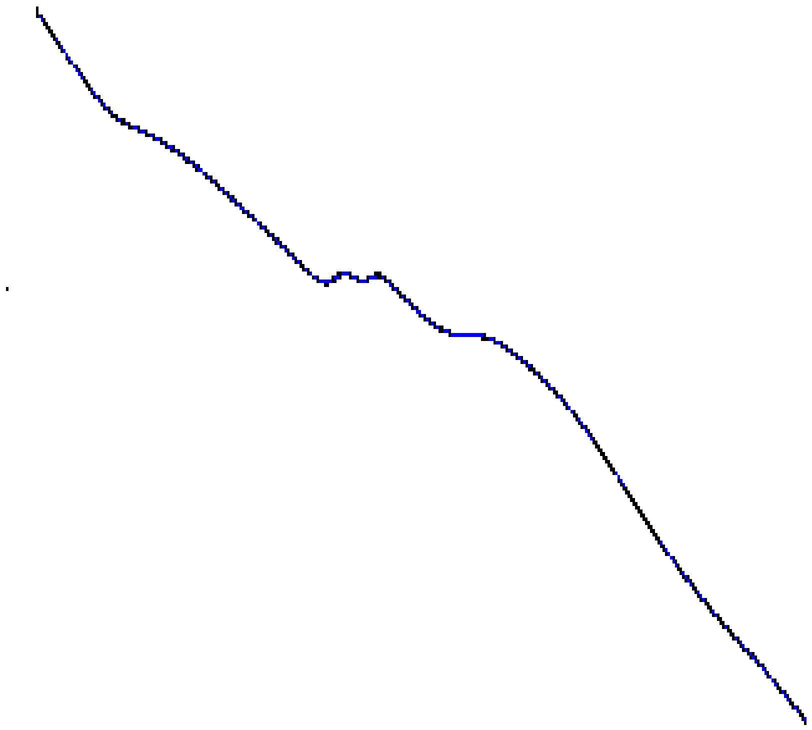
- Double Sided Printed Bow-Tie antenna were simulated with HFSS using a dielectric substrate with a dielectric constant of 6.15 without considering the dielectric loss.

- The Result shows an average return loss of -10dB from 2.2 to 9 GHz.



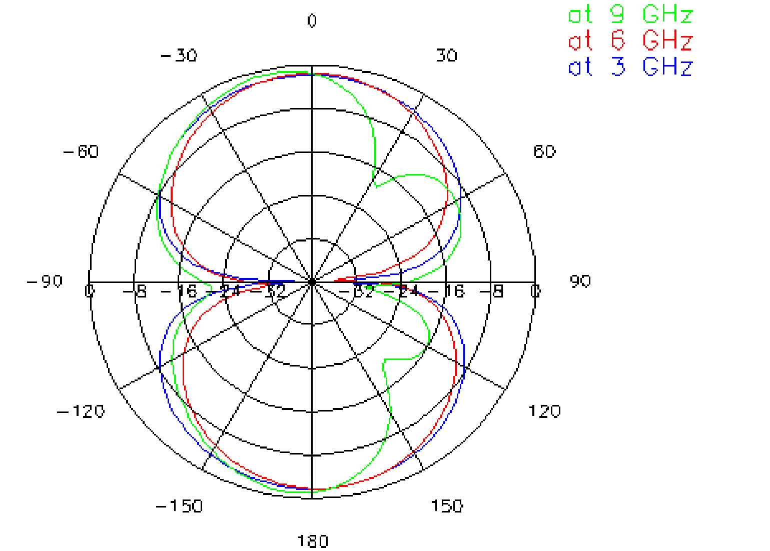
Results

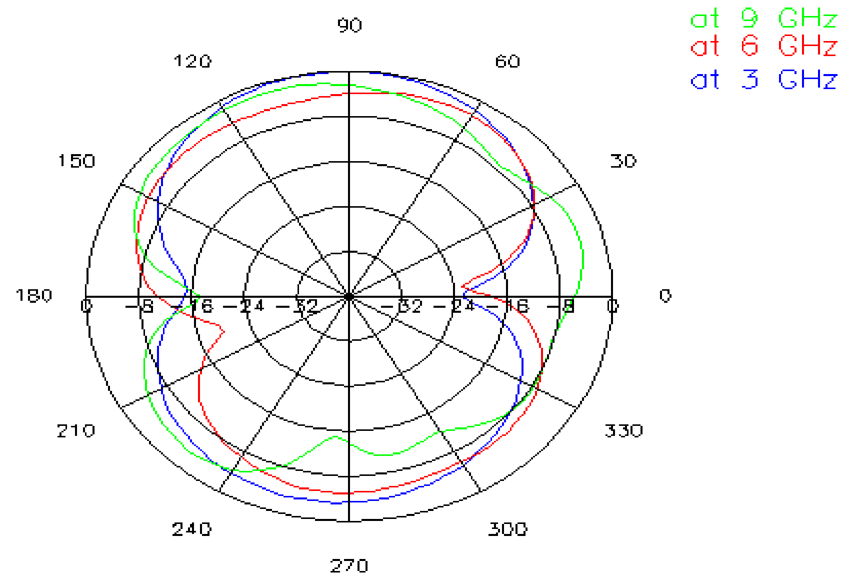
- The phase vs frequency plot of the Double Sided Printed Bow Tie antenna shows approximately linear phase .
- The phase linearity is directly connected to the group delay of the antenna.
- For the application of UWB, an antenna, which provide linear phase is needed.



Results

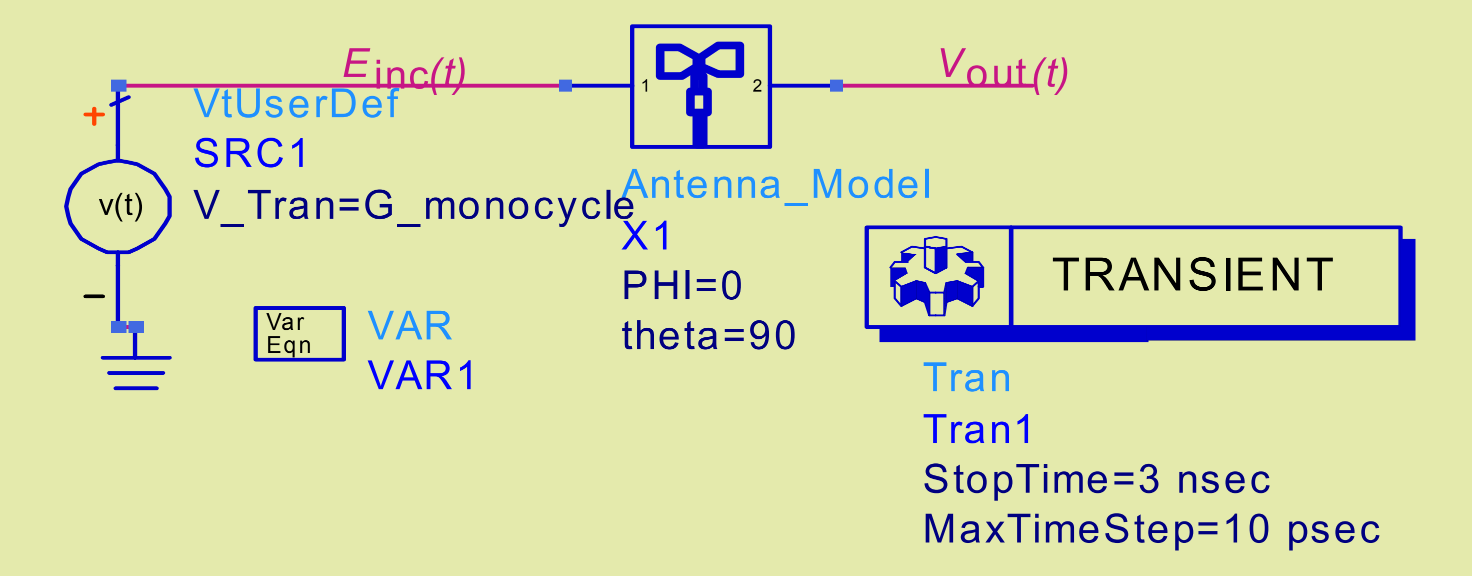
- Radiation pattern of DSPBT antenna in z-x plane(UP) and in x-y plane (down).
- The radiation patterns (in both planes) are taken at a frequncy of 3 GHz, 6 GHz, and 9 GHz.
- In both planes approximately constant radiation pattern are observed except at 30° and 140° in z-x plane and (0° - 30°) in x-y plane.





Model

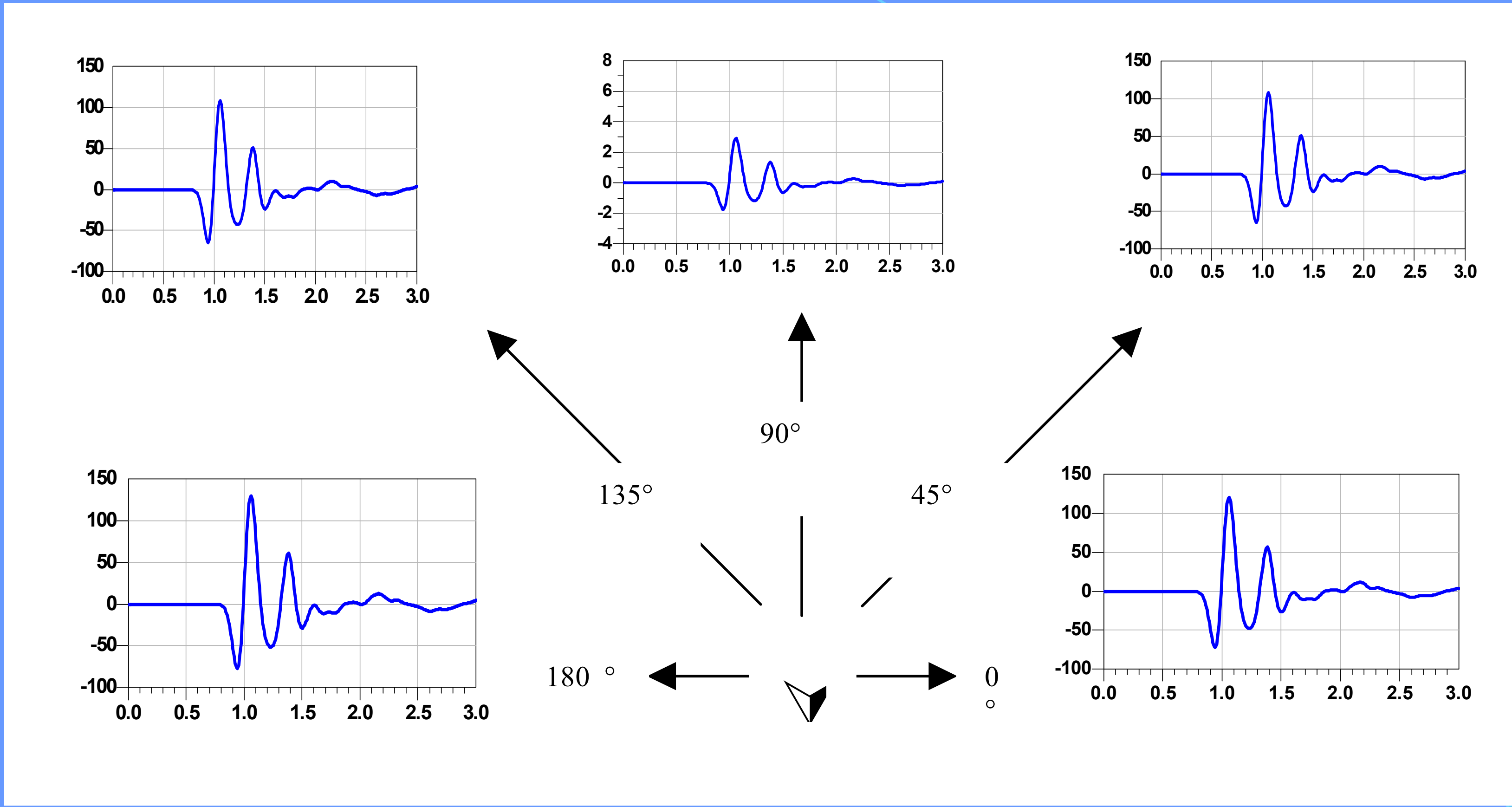
- The model was constructed based on the data transferred from HFSS.



$$V_{out}(t) = h(t) \otimes E_{inc}(t)$$

- The impulse response of the antenna contains the transfer characterstics of the antenna togather with the gain as a function of *frequency* angle *theta*, and angle *Phi*

Result

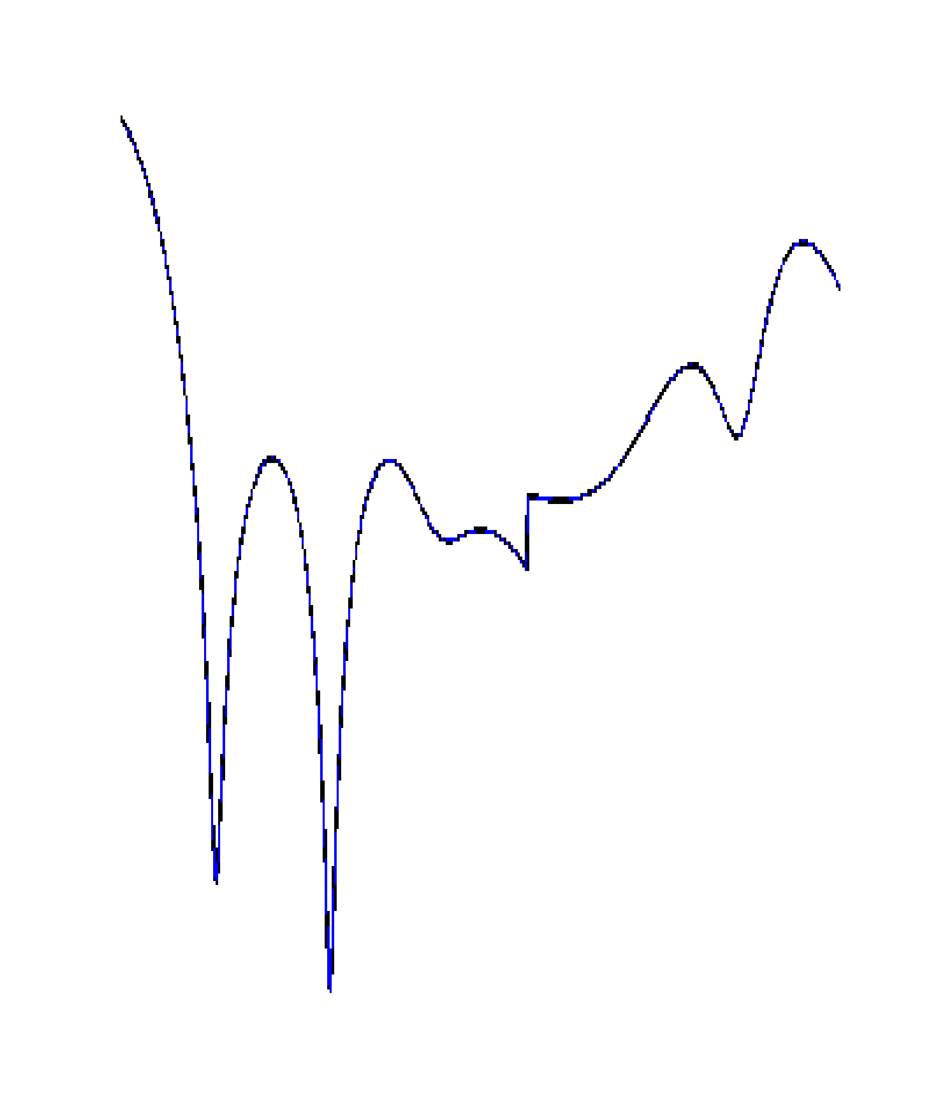


The response of the antenna in time domain (z-x plane)

Results

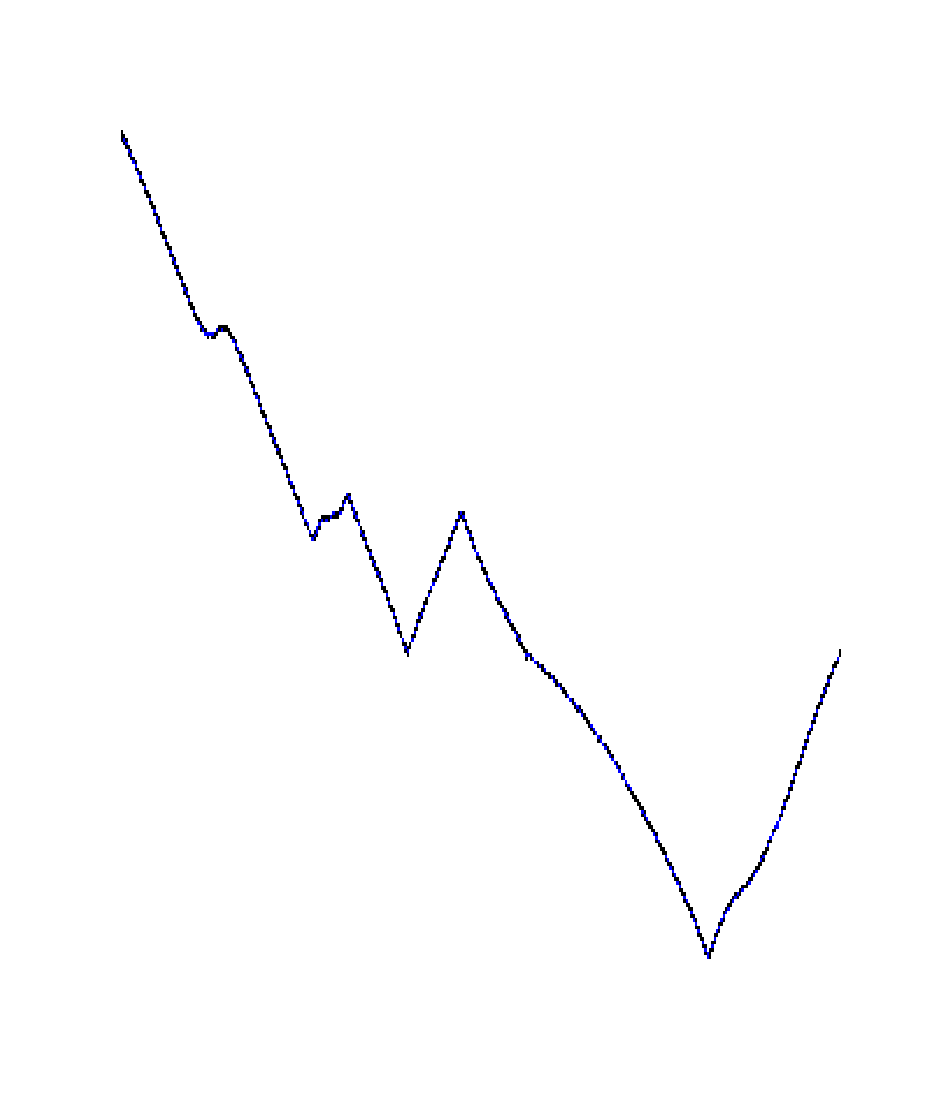
- Half part of the Balanced antipodal Vivaldi antenna was simulated with HFSS. The other half part is included by using H-plane Symmetry boundary condition.

- Return loss of this antenna shows –10dB and better in the band of frequency from 2.5 to 11GHz



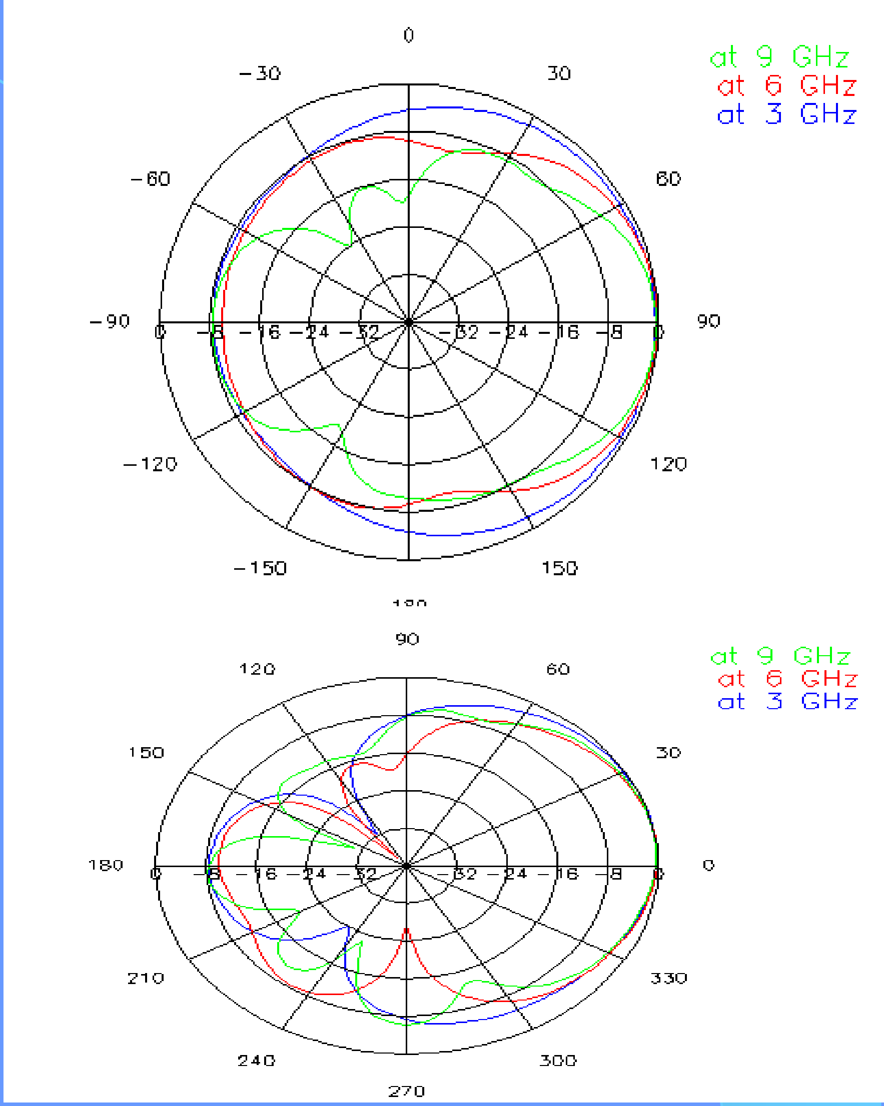
Results

- The phase vs. frequency graph of the antenna shows that the Balanced antipodal vivaldi antenna has a nonlinear phase response.

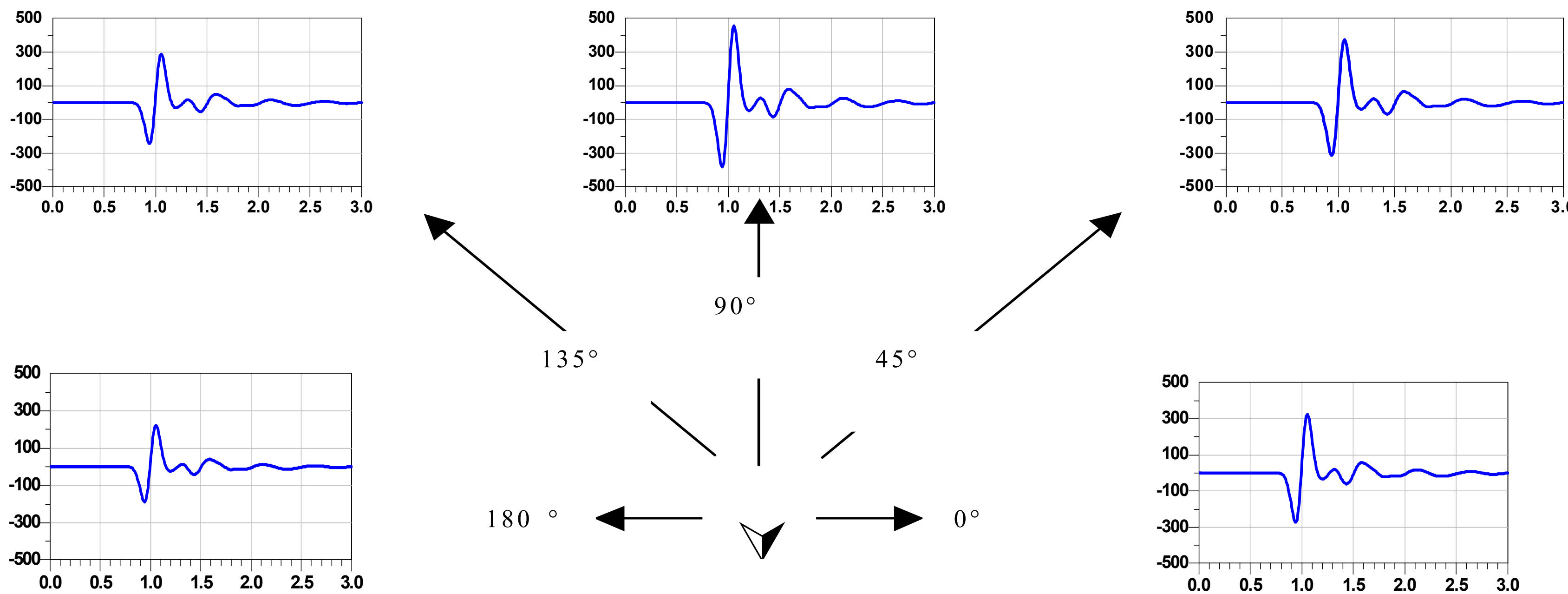


Results

- The radiation patterns of Balanced Antipodal Vivaldi antenna taken at 9 GHz, at 6 GHz, and at 3 GHz (above z-x plane and below x-y plane) show very broad directional radiation pattern.



Results

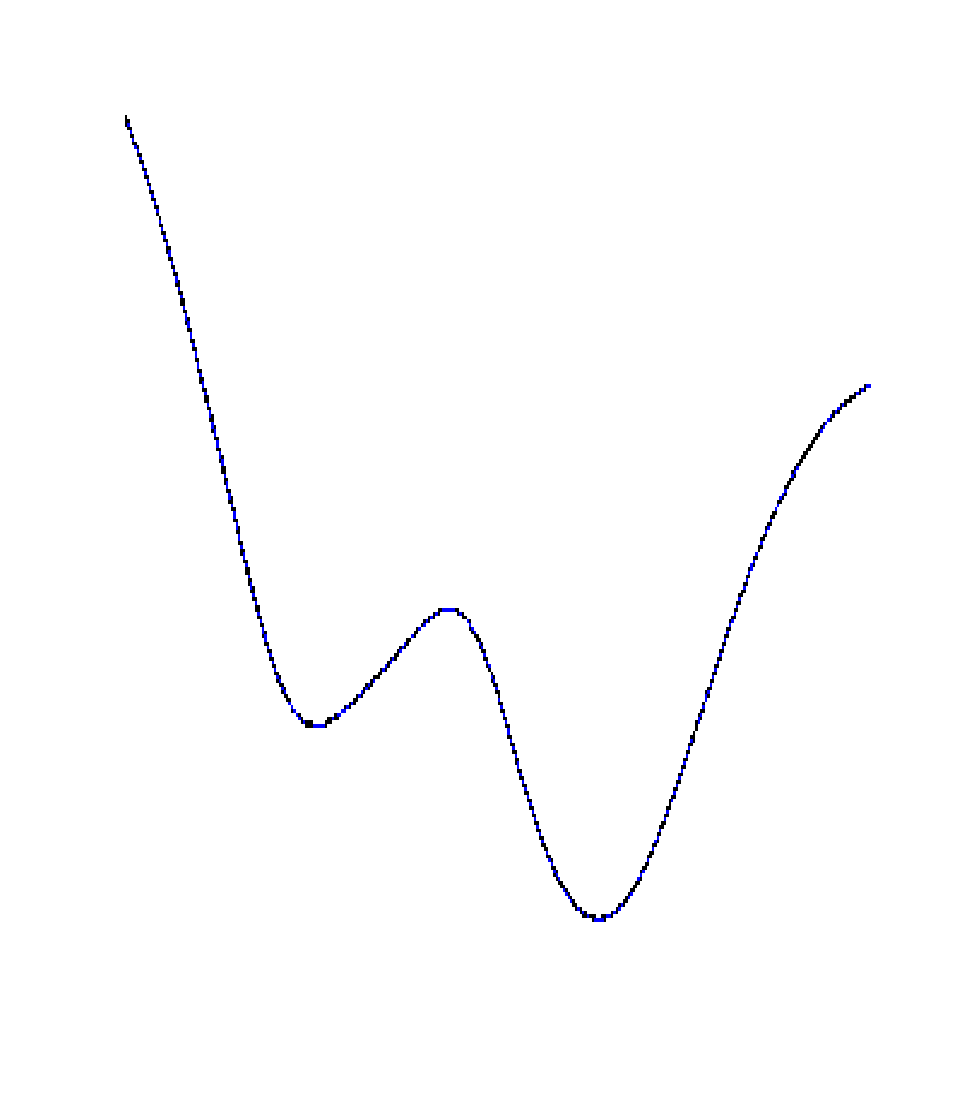


The response of the antenna in time domain (z-x plane)

Results

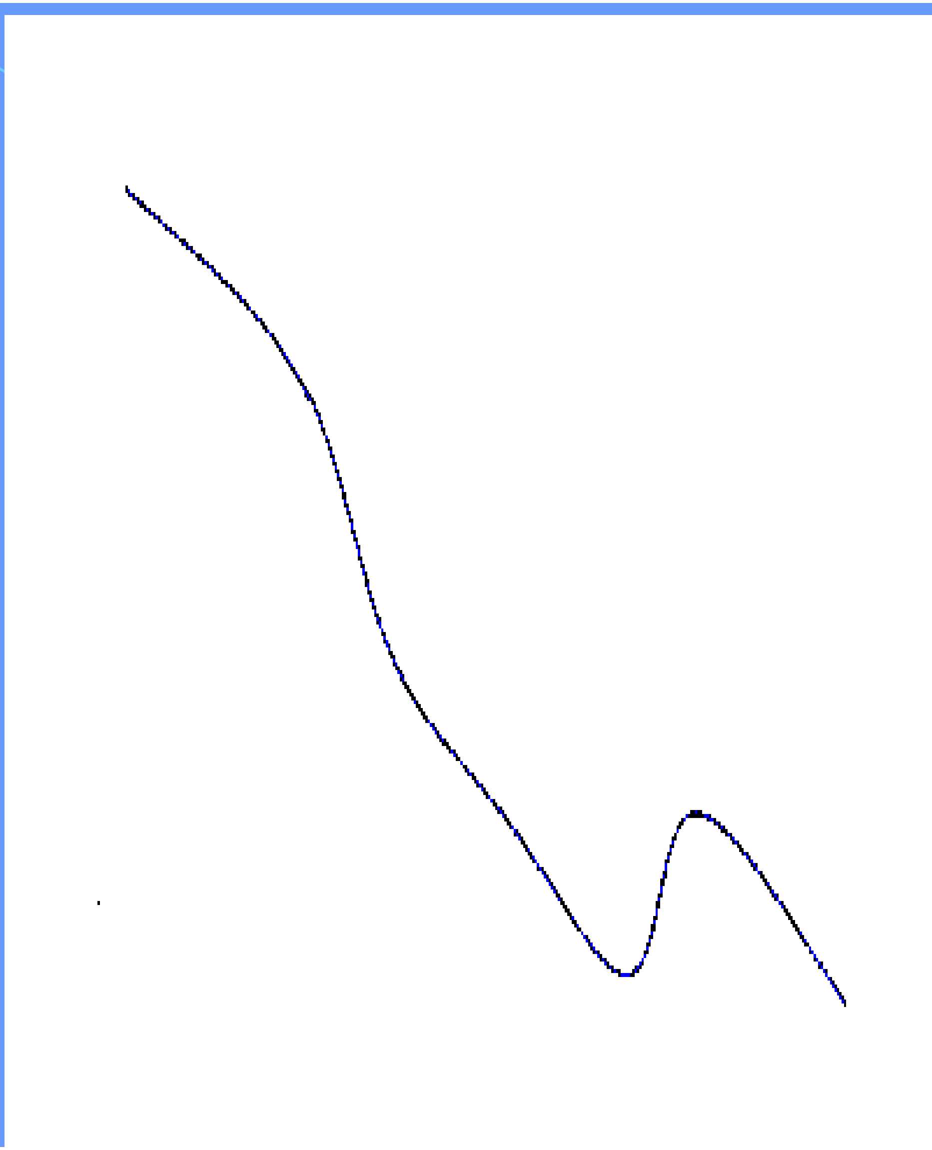
- The simulation result of New Planar UWB antenna using a dielectric substrate with a dielectric constant of 4.7 without considering the dielectric loss shows a return loss of – 10 dB in the range of frequency between

  3.1 to 11 GHz



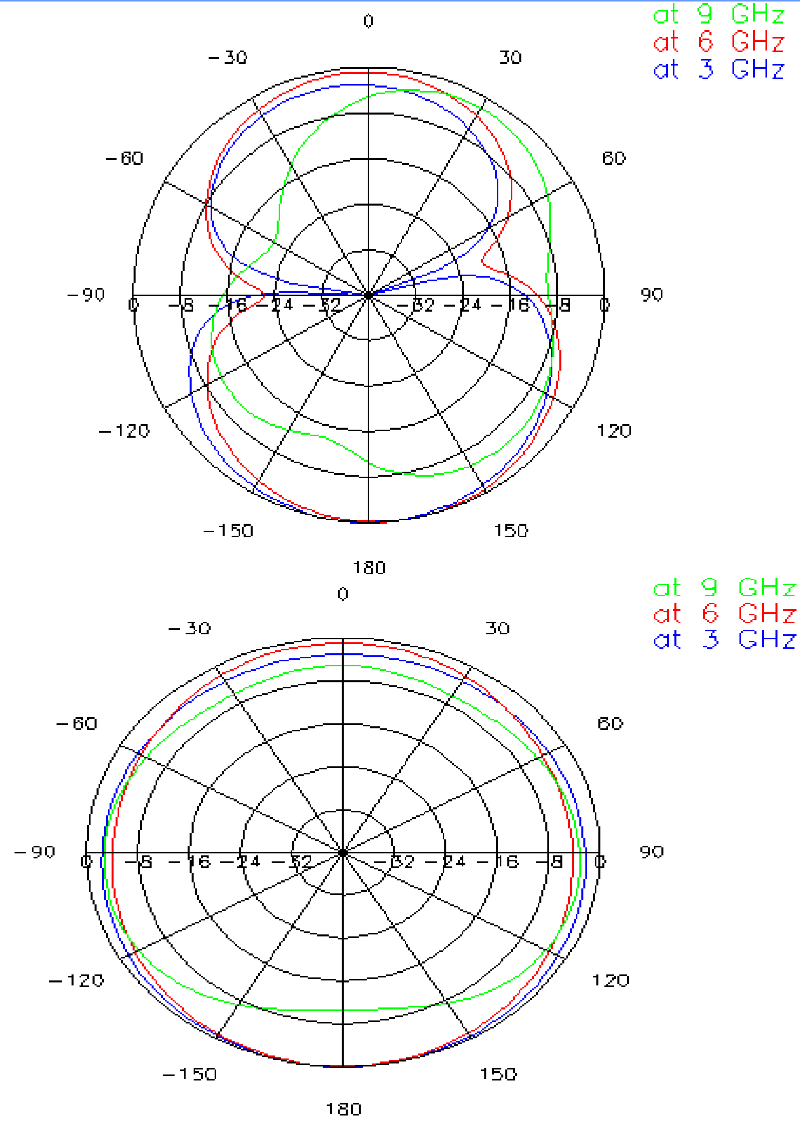
Results

- The phase vs frequency plot of the New Planar UWB antenna shows approximately linear phase from 2 to 8 GHz .



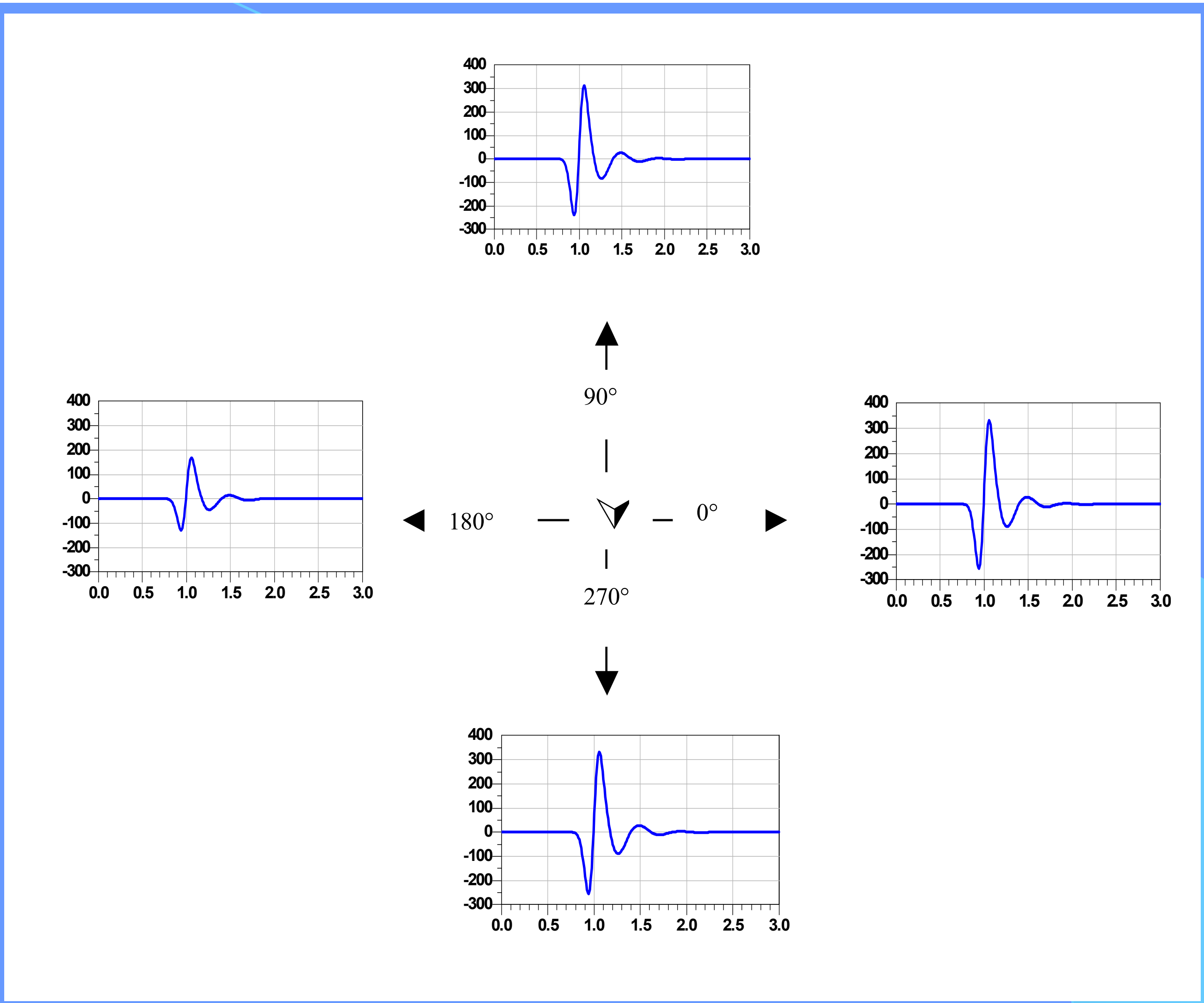
Results

- Radiation pattern of New Planar UWB antenna in z-x plane (UP) and in x-y plane (down) are shown in the figure.
- The radiation patterns (in both planes) are taken at a frequency of 3 GHz, 6 GHz, and 9 GHz.
- In both planes the radiation apttern taken at 3 GHz and 6 GHz shows approximatly constant radiation pattern.
- The pattern in the x-y plane shows approximately an omni-directional radiation pattern.



Results

- The response of the antenna in time domain (x-y) plane)



Summary and conclusion

- Average return loss of -10 dB from 2.2 – 9 GHz for Double Sided Printed Bow-Tie antenna, from 2.5 – 11 GHz for Balanced antipodal Vivaldi antenna, and a return loss of   –10 dB or better from 3.1 - 11 GHz for New Planar UWB antenna.

- The phase response of the antennas shows approximately linear phase for Double Sided Printed Bow-Tie antenna, non-linear phase for Balanced Antipodal Vivaldi antenna, and approximately linear phase for New Planar UWB antenna in the range of 2- 8 GHz.

- None of the simulated antennas show perfect constant radiation pattern in the whole UWB (3.1-10.6 GHz) frequency range.

Summary and conclusion

- However, the radiation pattern taken at 3 GHz and at 6 GHz are almost the same for the three antennas and the pattern taken at 9 GHz varies.

- The response of the antenna when excited with Gaussian Monocycle shows some ringing for Double Sided Printed Bow Tie antenna, a small ringing for Balanced Antipodal Vivaldi antenna and a very small ringing for New Planar UWB antenna.

Thank you

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