Designing And Development of Vivaldi antenna For UWB

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Abstract:- The objective of this paper is to design and develop a Ultra wide band Vivaldi antenna element for Hyperthermia Treatment . The antenna is required to operate from 2 GHz to 4 GHz. Element consists of an exponentially Tapered slot, which radiates the wave by traveling wave principle and a micro strip feed line. The transition from microstrip feed line to slot transmission line has been done with microstrip Radial stub. The suitable exponential taper has been employed to get proper radiation and good impedance matching. The proposed antenna has been designed and optimised for itselectrical performance and dimension by means of electromagnetic solver CST based on finite element method (FEM). The performance of Vivaldi antenna is tested corresponding to oil as background material. Results illustrate the potential of this structure for hyperthermia-treatment applicator design. The simulated results of the Vivaldi antenna element are in excellent agreement with the required ones, with a return loss better than –10 dB over the whole frequency band of 4GHz.

Keywords – Vivaldi antenna; Hyperthermia treatment; UWB Technology.

I. INTRODUCTION

Ultra-wide-band (UWB) antennas have an increasing demand in communication, radar, and EMI/EMC measurement systems. The antennas for such systems mustbe compact and lightweight for portability.

Besides the requirement on their compact size, gain stability, low cross polarization and broad bandwidth must be considered. This paper presents, Vivaldi element antenna because of its favorable characteristics for UWB application, and specifically they have relatively simple structure, light weight, and small lateral dimensions, wideband, high efficiency, and high gain characteristics. Vivaldi antenna provides a smooth transition between the guided wave travelling in the slot transmission line and the plane wave, which is radiated. This transition has been done by a gradual tapering of the slot line. Desired impedance and pattern band widths have been achieved by optimizing length, width and the tapered shape of aperture.

II. VIVALDI ANTENNA DESIGN

Vivaldi antennas designed using thin substrates with high dielectric constant would result in smaller size. But this also decreases the efficiency and bandwidth. Therefore, there must be a design trade-off between antenna size and good antenna performance. There are basically two typesof losses that occur in this type of antenna, the conductor

and the dielectric losses, both of which increase with frequency. Dielectric loss is related to the fact that all dielectrics contain polarized molecules that move in the presence of EM fields. High frequency fields oscillate very quickly and as the polar molecules move in sync with the field, they begin to heat the dielectric material. There is only one possible source for the heat i.e. the energy of the signal itself. It turns out that dielectric loss increases relentlessly with higher frequencies and in direct proportion to signal frequency. Hence, to keep the dielectric losses low at the frequency of operation, FR4 epoxy material of thickness 1.524 mm with a relatively low dielectric $\varepsilon r = 4.4$ and low loss-tangent (0.009) was chosen for this design. Proposed antenna has been designed and optimized in CST for required antenna characteristics. The CST model is shown in figure 2. The bottom layer shows the microstrip line and the radial stub used for feeding the tapered slot antenna. The top layer indicates the exponential tapered profile radiating element. The exponential taper is defined by the opening rate R and
starting point P_1 (x_1, z_1) and end point P2 (x_2, z_2) of the taper as given in equation below:. This is shown below in figure 1.

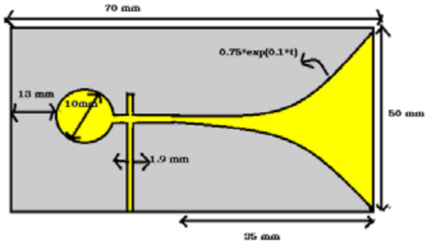


Figure 1: Schematic of Vivaldi Antenna

$$x = C_1 e^{Rz} + C_2$$

where

$$C_1 = \frac{x_2 - x_1}{e^{Rz_2} - e^{Rz_1}}$$

$$C_2 = \frac{x_1 e^{Rz_2} - x_2 e^{Rz_1}}{e^{Rz_2} - e^{Rz_1}}$$

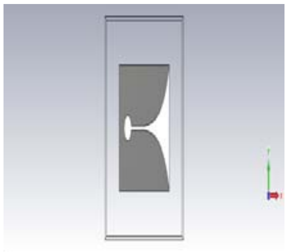
The length and the width of the tapered slotline to achieve the traveling wave mode of radiation generally need to be greater than λo and λo/2 respectively at lowest frequency of operation.

$$L > \frac{\lambda min+\lambda max.}{2} \quad W > \frac{\lambda min+\lambda max}{4}$$

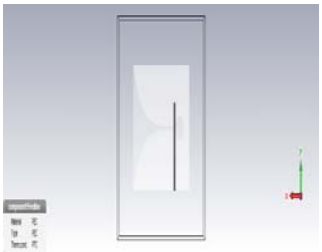
To achieve a broadband transition, the microstrip open stub and the slot line short stub are to present a virtual short and a virtual open at the point of transition, respectively. To that end, the radius of the radial Microstrip stub and the diameter of the circular slot stub may be approximated by $\lambda_m/4$ and$\lambda_s/4$, respectively. The λ_m is the effective wavelength of the microstrip and λ_s is the effective wavelength in the slot line.

III. EXPERIMENT AND RESULT

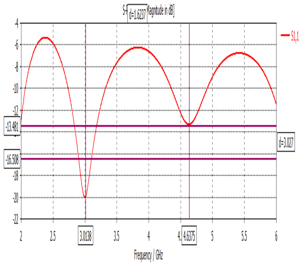
The Simulated and measured results are shown here for the proposed design. The simulated return loss is better than - 10 dB over whole frequency band of 3 and 4.6GHz is -20 and -12db.



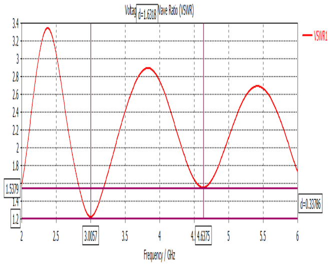
(a):- Front view



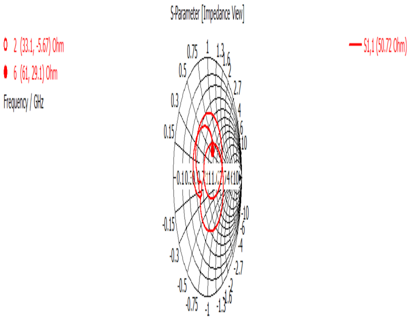
(b):- Back View



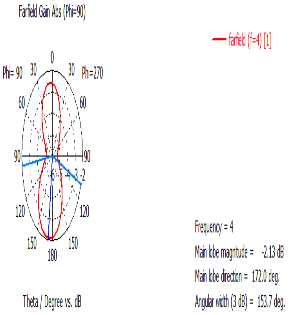
(c):- S- parameter



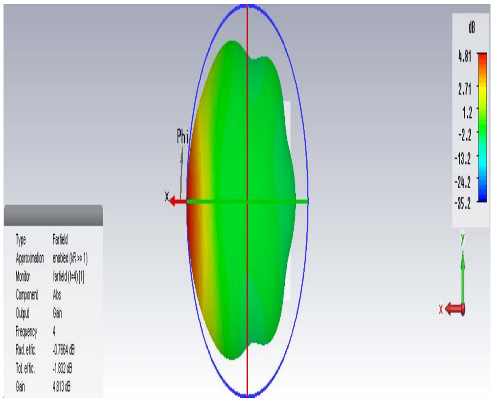
(d):- VSWR



(e):- the impedance matching is 50.73 ohm.

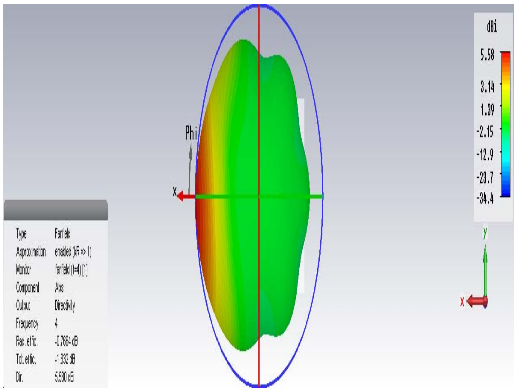


(f);- plor plot of farfield for frequency 4Ghz



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=4) [1]
Component	Abs
Output	Gain
Frequency	4
Rad. effic.	-0.7664 dB
Tot. effic.	-1.832 dB
Gain	4.813 dB

(g):- the gain of antenna is 4.81 dbi



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=4) [1]
Component	Abs
Output	Directivity
Frequency	4
Rad. effic.	-0.7664 dB
Tot. effic.	-1.832 dB
Dir.	5.580 dBi

(h):- directivity of antenna is 5.58dbi

IV.CONCLUSION

A wide band Vivaldi element has been designed which meets all the design goals. The measured VSWR < 2 from 2GHz to 6 GHz, the broadside gain 6.5 dB at centre frequency and E & H plane HPBW 530 and 680 respectively have been achieved. Hence this element may be suitable for Ground Penetrating Radar applications.

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