# Analysis and Design of Vivaldi antenna array using SIW Technology

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**Abstract -** In the short pulse wireless communication systems, since the information may be included in the shape of short pulses, the pulse distortion should be reduced to a minimum. Both TEM horn and Vivaldi antenna satisfy the requirements of UWB, but TEM horn is a 3D structure and not easy to integrate while Vivaldi antenna is a 2D one and easy to be integrated with radiating or transmitting elements on one circuit board to form a compact handset equipment. A compact Vivaldi antenna array printed on thick substrate and fed by a Substrate Integrated Waveguides (SIW) structure has been developed. The antenna array utilizes a compact SIW binary divider to significantly minimize the feed structure insertion losses. The low-loss SIW binary divider has a common novel Grounded Coplanar Waveguide (GCPW) feed to provide a wideband transition to the SIW and to sustain a good input match while preventing higher order modes excitation. Furthermore, since the slot line is a balanced transmission line while the feeding coaxial line or microstrip line is an un banlanced one, wideband balunis required. Emerging millimeter-wave frequency applications require high performance, low-cost and compact devices and circuits.

***Key Words*:** hfss, Finite element method, frequency selective surface, signal to noise ratio etc.

## 1.INTRODUCTION

SIW technology makes it possible to realize the waveguide in a substrate and provides an elegant way to integrate the waveguide with microwave and millimeter wave planar circuits using the conventional low-cost printed circuit technology. Since its inception, a vast range of SIW components, such as filters, phase shifters, transitions, couplers, power dividers, and diplexers, have been proposed Detection of insecured UAV is now critical challenge , Unmanned Aerial Vehicle (UAV), popularly known as Drone, is an airborne system or an aircraft operated remotely by a human operator or autonomously by an onboard computer. To detect the UAV many things are there as critical parameter i.e Frequency selection , resolution ,imaging signal processing transceiver design and Antenna system. Ku band can be chosen as per resolution and fractional bandwidth. Antenna system should be designed in such a way integration might be possible with other RF Subsystems .Waveguide with printed Antenna is very complex solution and microstrip transition with antenna with Antenna is low efficient solution , so in this work we propose SIW (substrate integrated waveguide ) Transition with antenna having moderate gain ,moderate efficiency and can be integrated with antenna and other RF subsystems in back hand .

An ideal antenna is one that will radiate all the power delivered to it from the transmitter in a desired direction or directions. In practice, however, such ideal performances cannot be achieved but may be closely approached. Various types of antennas are available and each type can take different forms in order to achieve the desired radiation characteristics for the particular application.

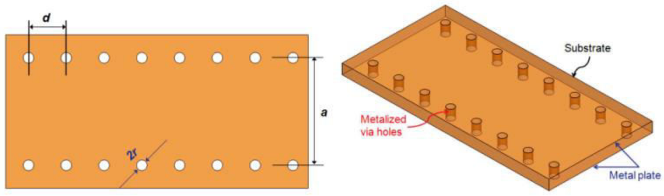



Fig- substrate integrated waveguide on dielectric substrate

## 2. VIVALDI ANTENNA

Antenna design is an important issue in the radar based microwave imaging. Traditional methods of antenna design assume that antenna is in the free space. However, for antenna design in radar based imaging, it is assumed that the antenna will lie close to the breast in the near- field. The pulse generated from the antenna is radiated into a bio- like tissue. This bio- like tissue has similar electrical properties to those of the body tissue which surrounds the breast in order to reduce the electrical property discontinuity ca used strong reflection from the skin layer. Another issue regarding antenna design is its dimensions. The multi- static radar system uses an antenna array; hence, the geometrical dimension of the antenna must be as small as possible in order to maximise the number of antennas used in the array and this, in turn, will increase the working frequency and the penetration of electromagnetic energy into the breast will be insufficient. Another issue of concern is mutual coupling. Mutual coupling means that one antenna can generate an induced current due to the current flowing in adjacent antennas. This induced current could change the impedance of the antenna, the radiation pattern and the scattering parameters which makes the antenna's properties unpredictable. Hence, the dimensions of the antenna and mutual coupling are the major challenges in antenna design for multi-static radar based imaging system . However, the mono-static radar system uses a single antenna or an antenna pair to scan the breast with mechanical movement. Hence, the design of antennas focuses only on its gain, bandwidth, and fidelity.

Ultra-wideband technology has been widely used in the radar and wireless Ultra-wideband technology has been widely used in the radar and wireless communication fields for a long time. UWB systems use very short pulses (normally a few nanoseconds) and this, results in an ultra wideband spectrum. The use of UWB provides several advantages, such as high capacity, low power transmission and high reliability. Besides, another important application for UWB is radar based microwaving. The use of UWB provides high resolution in the resulting images due to the high bandwidth spectrum. Normally, the UWB working frequency contains both low and high frequency contents. The low frequency component provides a high penetration ability to detect relative deeply buried tumours while the high working frequency component lacks the penetration ability but offers high resolution to detect relatively small tumours. Hence, this unique feature is especially suitable for radar based breast cancer detection.

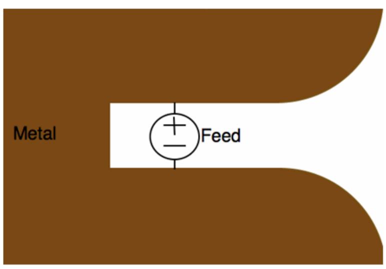



Fig- Geometry of Vivaldi antenna

## 2.1 The Equivalent circuit model

An equivalent circuit schematic of the Vivaldi antenna is shown in Fig 3.4, Here, $Z_m$ and $Z_s$ indicate the characteristic impedance of the microstrip line and the slotline respectively. $L_m$ and $C_s$ show the equivalent inductor and capacitor of the microstrip line and the slotline respectively. $X_m$ and $X_s$ denote the input reactance of the microstrip line and the slotline respectively. $Z_{ant}$ indicates the impedance of the cross-section of the slotline and microstrip line.

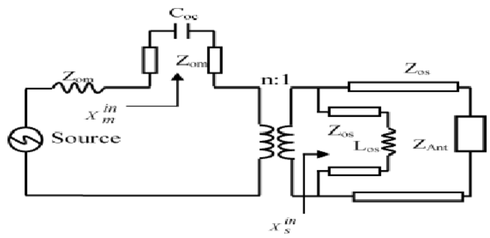
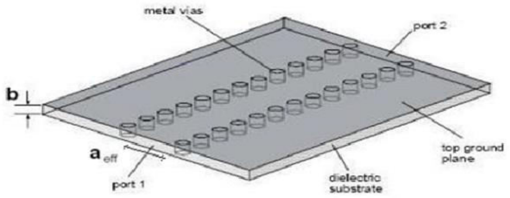



Fig- Equivalent circuit model of vivaldi

## 3 SUSTRATE INTEGRATED WAVEGUIDE

SIW structures are fabricated on printed circuit boards. Its emulated waveguide SIW sidewalls are constructed from lined via-holes rather than the solid fences used in conventional metallic waveguides. This technology is simple, less expensive than its predecessors, and even renders light structures. Ultra-wideband (UWB) antennas are a class of broadband antennas with considerably wide bandwidths. Following is a definition for UWB antennas, according to their impedance bandwidths, communicated by the Federal Communications Commission (FCC). here we utilize this technology to develop a Vivaldi wideband antenna array with a relatively low insertion loss.

A promising candidate for overcoming this limitation at high frequency is substrate-integrated waveguide (SIW) technology. Substrate Integrated Waveguides (SIWs) are planar structure which are fabricated by using two periodic rows of metallic cylindrical slots implanted in a dielectric substrate that electrically unite both parallel conducting plates. Apart from this, the most key advantage of SIW technology is the viability to incorporate active and passive components on the same substrate. Also more chip-sets can be mounted on the same substrate. Table 1 summarizes the characteristics of different UWB antennas. The Vivaldi antenna belongs to the tapered slot antennas (TSA) class and there are good candidates for wide band performance. The Vivaldi antennas are extremely suitable for UWB antenna applications due to their varied features.




## 4 DESIGN PARAMETERS

The key parameters of SIW design are spacing between the vias "P" also called pitch, diameter vias "D", central distance between via arrays "Ar" also called integrated waveguide width, and the equivalent SIW width "Ae". The SIW parameters should be designed carefully. The pitch "P" and diameter "D" control the radiation loss and return loss, while the integrated waveguide width "Ar" determine the cut-off frequency and propagation constant of the fundamental mode. There are two design rules related to the pitch and via diameter as given by:

$$D < \frac{\lambda_g}{5} \quad \text{.....................(1)}$$

$$P \leq 2D \quad \text{.....................(2)}$$

Where λg is the guide wavelength in the SIW. The cut-off frequency of an SIW can be determined by :

$$f_c = \frac{c}{2\sqrt{\varepsilon_r}}\left(A_r - \frac{D^2}{0.95P}\right)^{-1}$$

Where c is the speed of light in vacuum and εr is the relative permittivity of dielectric material. The equivalent SIW width "Ae" is the width of rectangular waveguide whose modes exhibit the same propagation characteristics of the SIW modes. It can be found by:

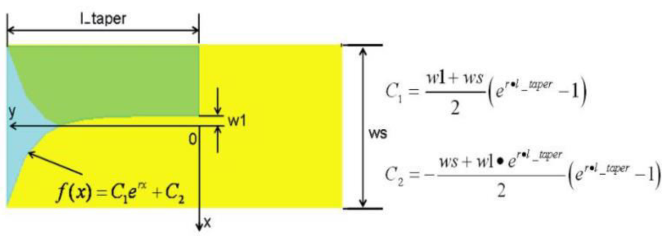
$$A_e = \frac{a}{\sqrt{\varepsilon_r}}$$

### 4.1 Design of Feeding network

this type of SIW feeding network can provide a balanced power division over a wide band. Both the balanced power split and low insertion loss should assist with increasing the gain and overall efficiency of the antenna array. Meanwhile, the use of thick substrates and optimized T-junctions has created an improvement in performance. At the same time, the input port has a commendable return loss over the 7 to 9 GHz frequency range.

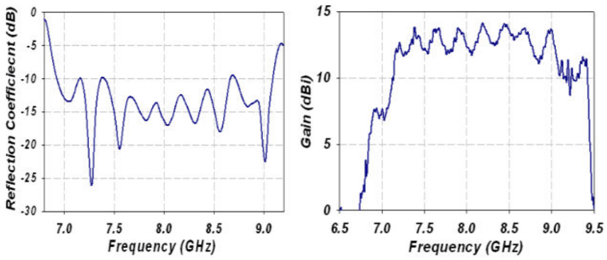
### 4.2 Single Element antenna Design

Utilizing SIW technology, a number of UWB antenna structures can be used. Included are H -plane horns, slot antennas, tapered-slot traveling wave antennas, etc. H -plane horns would require extremely thick substrates in order to achieve a low return loss over a wideband. This would increase the system's overall cost. Meanwhile, slot antennas have the advantage of being small and can be used in a traveling wave array configuration to form a 2D-array. However, the differential phase shift between the elements will change with frequency, causing a beam squint. To have the beam direction constant with frequency, SIW feeding tapered slot antennas have been chosen. The utilized taper can be linear (LTSA), exponential (Vivaldi), elliptical, or constant width (CWTSA) [23]. Linear elements are generally easier to design due to the relatively small number of parameters that need to be optimized. However, the elements need to be long enough to be a good match over a wideband, as described in [15], where an 80 mm taper length was utilized. Instead of using the wideband balun, a SIW has been employed to feed a Vivaldi antenna.



## 5 RESULT

In this we have discussed the simulation results obtained by running HFSS for parameter synthesis of proposed antenna. Essential parameter to design Antenna is s-parameters which is also measure of return loss of filter, VSWR, group delay, impedance of the antenna for entire frequency range for which antenna is designed.




## 6. CONCLUSIONS

Performance of Vivaldi antenna arrays can be enhanced using low-loss feed networks. SIW technology with emulated waveguides can be utilized to minimize such losses, especially when compared to similar structures built using microstrip lines. In our implementation, the SIW structure was optimally designed and fabricated on a thick substrate to minimize the conductor losses, and has led to significant reduction of feed losses. The developed array employs a SIW binary divider to minimize the insertion loss of the feeding network, but it requires the development of a special SIW to GCPW transition to sustain a satisfactory input match while preventing higher order modes excitation over a wide frequency range. Use of optimized T-junctions and the integration of a wideband GCPW feed have led to an even more improved performance with a significant loss reduction.

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