Design of High-Gain Ka-Band Antipodal Vivaldi Antenna excited by Printed Ridge Gap Waveguide

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***Abstract*—This paper presents the design of Antipodal Vivaldi antenna (AVA) excited by a low-loss waveguiding structure commonly known as printed ridge gap waveguide (PRGW). The simulated result shows the designed antenna has wide impedance matching and an average gain of 13.5 ($\pm$1) dBi after dielectric loading over Ka-band.**

***Index Terms*—Printed Ridge Gap Waveguide (PRGW), Antipodal Vivaldi Antenna (AVA), mm-wave, Ka-Band**

I. Introduction

Since the evolution of accessing internet at our finger tips, the demand for increase in data rates have been greatly increased. Electronic devices such as smart television, smart watch, smart home etc. which work on the principle of Internet of Things (IoT) require high data rates for communication in near future. In addition to existing connected devices autonomous vehicles, cellular networks [1] do need gigabytes per second data rates in order to receive and transmit information within few secs, which pushes radio frequency components to design and operate in millimeter wave (mm-wave) frequencies.

Traveling wave antennas such as Vivaldi antenna are known for achieving broad bandwidth, high gain, low x-pol etc. are suitable to operate at mm-wave frequencies. These antennas are used in radar and wireless applications [2], [3].

Micro-strip line, non-planar waveguides etc. were primarily used in order to transmit energy in a bounded medium from source to destination. But as frequency increases, dielectric loss increases in micro-strip lines; waveguides will be tiny hence they are difficult to manufacture. Thus, low or no-loss and planar transmission lines are preferred at mm-waves.

One such guiding structure is developed based on the concept of Hard and Soft surfaces [4], which allows the wave propagation to travel in free-space between two parallel Perfect Electric Conductor (PEC) plates surrounded by Artificial Magnetic Conductor (AMC). When the distance between PEC and AMC is less than quarter wavelength no waves will be propagated in undesired direction and thus increasing the efficiency of transmission from one port to another [5], [6].

II. PRGW Configuration

A PRGW comprised of unit cells and a ridge is shown in Fig. 1. For the design of unit cell, a square metal mushroom has been printed on Rogers 6002 substrate having ϵ_r of 2.94. Via with diameter 0.4 mm has been inserted into the substrate height of 0.762 mm. An air gap of height 0.508 mm is introduced between the mushroom and top metal. The band gap achieved for the designed unit cell is from 22 – 42 GHz, simulated using CST Eigen mode solver by choosing x, y axis as periodic and z axis as PEC boundary condition.

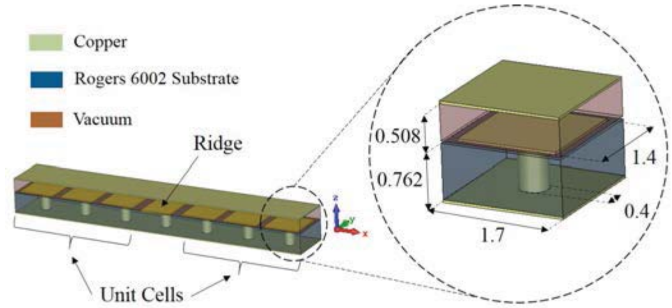

Fig. 1. A row of PRGW structure (units: mm)

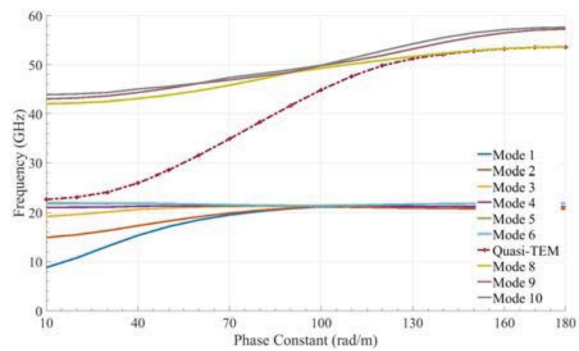

Fig. 2. PRGW Dispersion Diagram

Fig. 2. depicts dispersion diagram for Fig. 1, Quasi–TEM mode propagates along the ridge oriented parallel to Y-axis from 22 – 42 GHz when group of unit cells are periodically aligned along the ridge.

III. AVA Design

A single AVA measuring $3.5\lambda_0 * 1.5\lambda_0$ (where λ_0 is the free space wavelength at 30 GHz) in length and width is printed on Rogers 6002 substrate with ϵ_r = 2.94 of height 0.508 mm as shown in Fig. 3. The antenna is excited using PRGW where transverse Electro-Magnetic (EM) waves travel in free space between ridge and top metal. Furthermore, a

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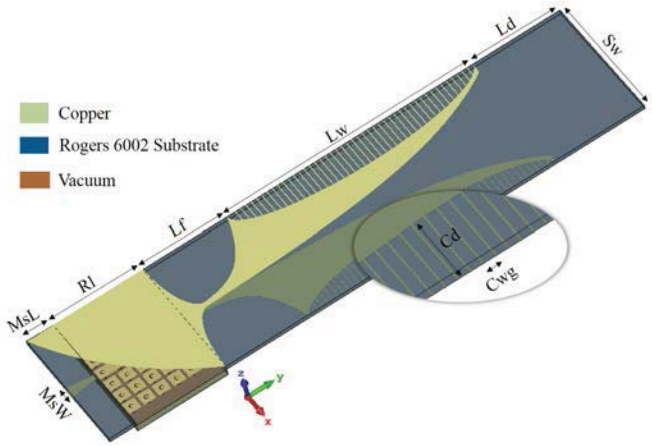

Fig. 3. AVA fed by PRGW

TABLE I
AVA PARAMETERS

Parameter	Value (mm)
MsL	3
Rl	10.2
Lf	9.5
Lw	28
Ld	10
Sw	14.7
Cd	3.5
Cwg	0.6
MsW	1.24

micro-strip line ($Z_0 = 50\Omega$) transition is constructed as input to PRGW. Antenna dimensions are mentioned in Table-1.

In order to increase gain of the antenna and to reduce side-lobes, dielectric substrate has been extended in the direction of aperture and corrugations varying in length along the ellipse trace has been etched on antipodal structure of antenna respectively.

IV. SIMULATION RESULTS

The designed AVA was simulated on CST Microwave Studio (CST MWS) and High Frequency Structure Simulator (HFSS). The plot of scattering parameter (S11) and realized gain versus frequency is shown in Fig. 4.

Fig. 5 shows E (XY plane) and H (YZ plane) radiation pattern at 26, 30, 34 and 38 GHz frequencies.

V. CONCLUSION

A low-loss wave guiding structure traveling nearly at speed of light has been designed to excite AVA and proves to be one of the efficient way to transmit energy from one point to another at mm-wave frequencies. Simulated AVA from both EM softwares shows promising results in achieving nearly 42% of wide bandwidth and 12.5-14.5 dBi of realized gain for Ka-band of frequencies.

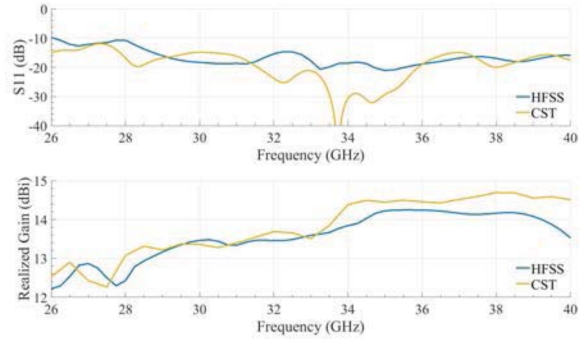

Fig. 4. Plot of S11 (dB) and Realized Gain (dBi) versus Frequency (GHz)

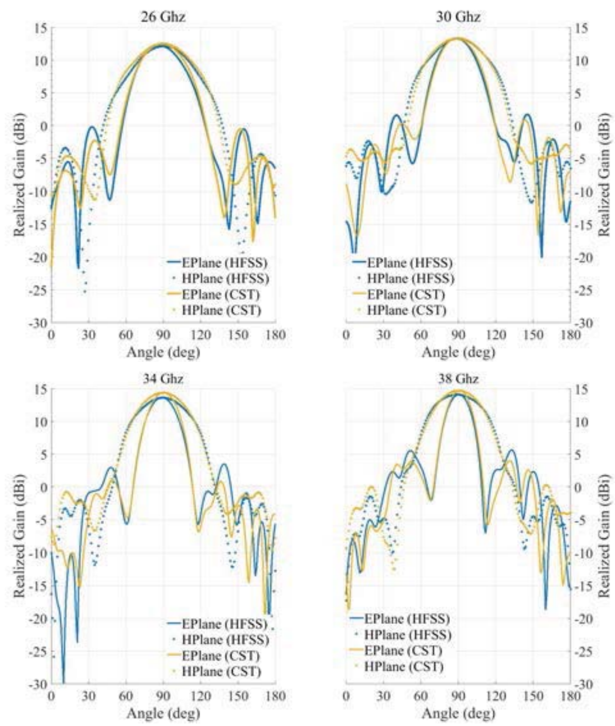

Fig. 5. Radiation Pattern at 26, 30, 34 and 38 GHz

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