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# Antipodal Vivaldi Antenna for Passive Imaging Technology in Ka Frequency Band

Mehmet Duman*[1], Alp Oral Salman

## ABSTRACT

Antenna is one of the most important part in Passive Millimeterwave Imaging (PMI) Technology which is used to view scene in foggy air conditions or to see concealed weapon under clothes that cannot be seen other technology because of the materials of weapon. There are some frequency windows to work with PMI Technology as 35, 96 and 220 GHz and it is near 35 GHz frequency window for this work. Antipodal Vivaldi Antenna has 50.07 ohm input impedance, Z, for matching, and -39.23 dB input reflection coefficient, $S_{11}$, and 6.82 dB gain, G, is designed for 35.18 GHz center frequency in Computer Simulation Technology (CST) Program. The antenna has 110 MHz bandwidth and it can work between 35.23 GHz and 35.12 GHz frequencies. After the antenna is connected to the amplifier or detector circuits, the created system will be integrated into a scanner which is capable of scanning azimuth and elevation axes. As a result, PMI System will be formed and ready to view the scene or the hidden things in haze air conditions.

**Keywords:** Antipodal Vivaldi, foggy air conditions, passive millimeterwave, scanning axes

## 1. INTRODUCTION

In this work, a kind of two-faced Vivaldi Antenna (VA) is designed. The half of the VA is on top of the one surface and the other half of the VA is on the other surface of the two-faced copper plate. Because of this structure, it is named Antipodal Vivaldi Antenna [1]. The circle section was removed from the leaves of the antenna in each face of the copper plate. Therefore, the electric field will be centered easily [2]. In addition, the current density will also be at the midpoint of the antenna. The protrusion shapes which are at the end of the antenna leaves will move the surface currents and power flow to the desired sections of the antenna [3]. First of all, the form of antenna is given in material and shape features. Later, the figures of merit are calculated [4] and measured in CST. Finally, the antenna with 50.07 ohm input impedance, $Z_{in}$, 6.82 dB gain, G, and -39.23 dB input reflection coefficient, $S_{11}$, is designed for 35.18 GHz working frequency for Passive Millimeterwave Imaging Systems [1]. The designed PMI System as a sensor [5] consist of radiometer [2], [6] will scan the azimuth and elevation axes [7] and it might view the scene in haze air conditions or the hidden things under the clothes [8].

## 2. FORM OF ANTENNA

### 2.1. Materials

Annealed lossy metal type copper is used for the conductive part.

The properties of this copper are given below.

* Mehmet Duman, Kocaeli Üniversitesi Mühendislik Fakültesi Elektronik ve Haberleşme Mühendisliği Doktora Öğrencisi
[1] Düzce Üniversitesi Teknoloji Fakültesi Elektrik Elektronik Mühendisliği, Araştırma Görevlisi, mehmetduman@duzce.edu.tr

$$Permeability\ factor\ (Mue, \mu_r) = 1 \quad (1)$$

$$Electrical\ cond. = 5.8 \times 10^7\ [S/m] \quad (2)$$

$$Rho = 8930\ [kg/m^3] \quad (3)$$

$$Thermal\ cond. = 401\ [W/K/m] \quad (4)$$

$$Heat\ cap. = 0.39\ [kJ/K/kg] \quad (5)$$

$$Diffusivity = 0.000115141\ [m^2/s] \quad (6)$$

Normal type Diclad880 with 2.2 permittivity factor, epsilon, $\epsilon_r$, was used for the ground.

The Diclad880 has 0.009 tan $\delta$ value.

### 2.2. Shape of Antipodal Vivaldi Antenna

The antenna has 65 mm width and 80 mm length. The extracted round compartments and additional sections added to the leaves can be seen in Figure 1 and 2. The annealed copper width is 0.04 mm and the Diclad880 has 0.76 mm width.

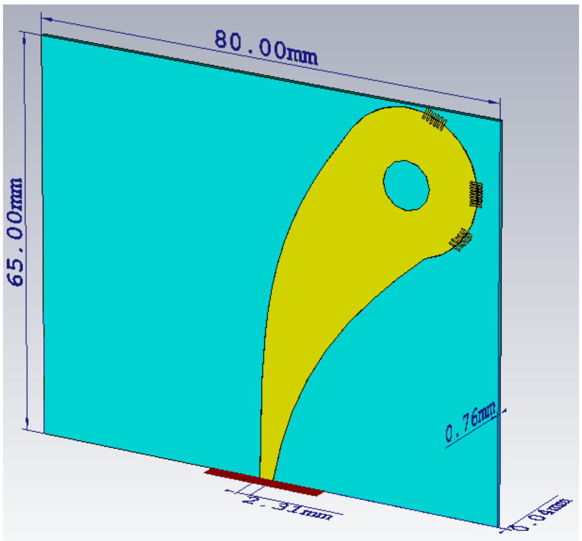


Figure 1. Perspective view of the antenna

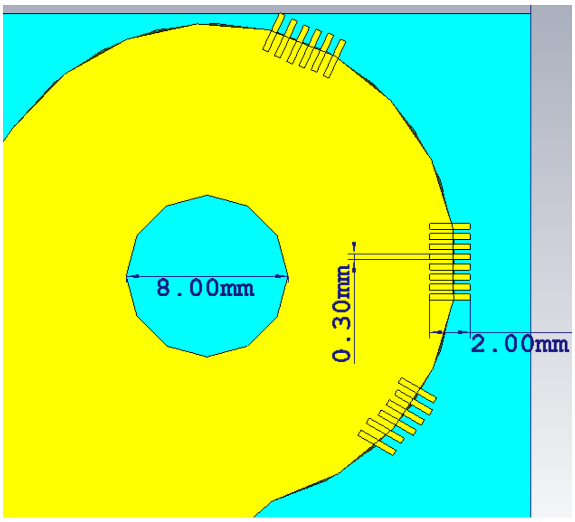


Figure 2. One of the leaf of the antenna

## 3. FIGURES OF MERIT

$S_{11}$ value should be under -20 dB and the input impedance has to be 50 ohm for perfect matching [1], [4], [9]. Voltage Standing Wave Ratio (VSWR) should be close to 1 dB [9-10]. Electric field, current densitiy, surface currents and power flow [2], [11] are the other important figures of merit of the design.

### 3.1. $S_{11}$ Coefficient

For 35.18 GHz operating frequency the input reflection coefficient, $S_{11}$, has the minimum value -39.23 dB. There are some other minimum values under 34 GHz but this experiment is done for PMI System frequency windows and under 34 GHz is not inside these windows. Thanks to the low value of $S_{11}$, the reflections from the input are at the minimum value, and the maximum power is transmitted. Detected signal from input is also transmitted to the output at the highest amount [9]. The $S_{11}$ graph which is obtained from CST can be seen in Figure 3.

### 3.2. 50 ohm Matching

50.07 ohm impedance value was achieved in this study. Most of the Radio Frequency (RF) circuits have 50 ohm impedance [1], [4], [11-13] so there will be perfect matching with the other circuits [7], [9]. In Figure 4, the impedance value can be seen on graph.

### 3.3. Gain of Antenna, G

The G value, in other words, gain should be close to 10 dB [1], [9], [11]. In this design, it is 6.82 dB. The gain, which is the ratio of the output voltage to the input voltage is directly related to the how much of the incoming signal is transmitted to the output [9]. The gain graph is on Figure 5. Above the 35 GHz there is bigger gain value but the other performance parameters are not good for that frequencies.

### 3.4. Surface Current

The properties of the antennas may differ depending on the situation and where they are used. It is desired to collect the surface currents at the midpoint rather than the dispersion in this antenna [10]. As it can be seen from the arrows in Figure 6, the surface current is not branched to leaves. In order to perform this feature, the leaves have been formed specifically.

### 3.5. Power Flow

Power flow characteristics are similar to the surface current characteristics [10]. In order to carry the flow of power to the desired zones, rounded sections were removed from other parts of the leaves. Furthermore, the direction of intensity of the power flow was determined by attaching protrusion shapes to the ends of the leaves [3]. The final figure of the power flow characteristic feature can be seen in Figure 7.

### 3.6. VSWR

VSWR value should be near 1 [9-10] and for this PMI System antenna it is 1.02 and the graph can be seen in Figure 8.

### 3.7. E-Field

As seen in Figure 9 and 10, the electric fields are spreading just like horn antennas for Transverse Electromagnetic (TEM) modes [1-2], [4], [11]. In this study, because of the working principle of passive circuits, the antenna will be the receiver, not the transmitter [7].

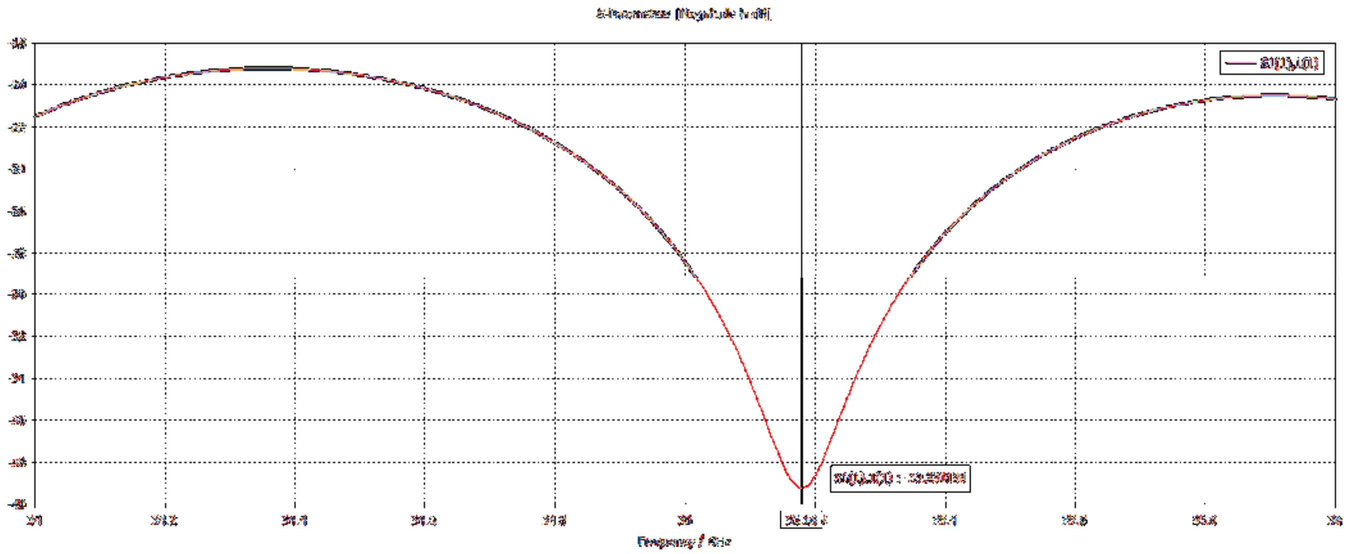

Figure 3. Input reflection coefficient graph from CST

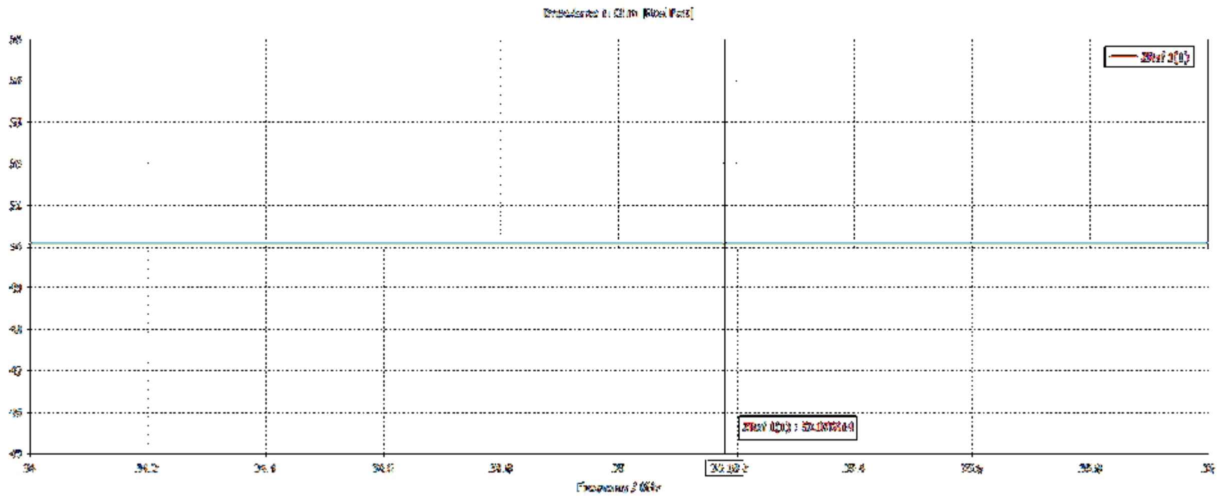

Figure 4. Impedance value graph

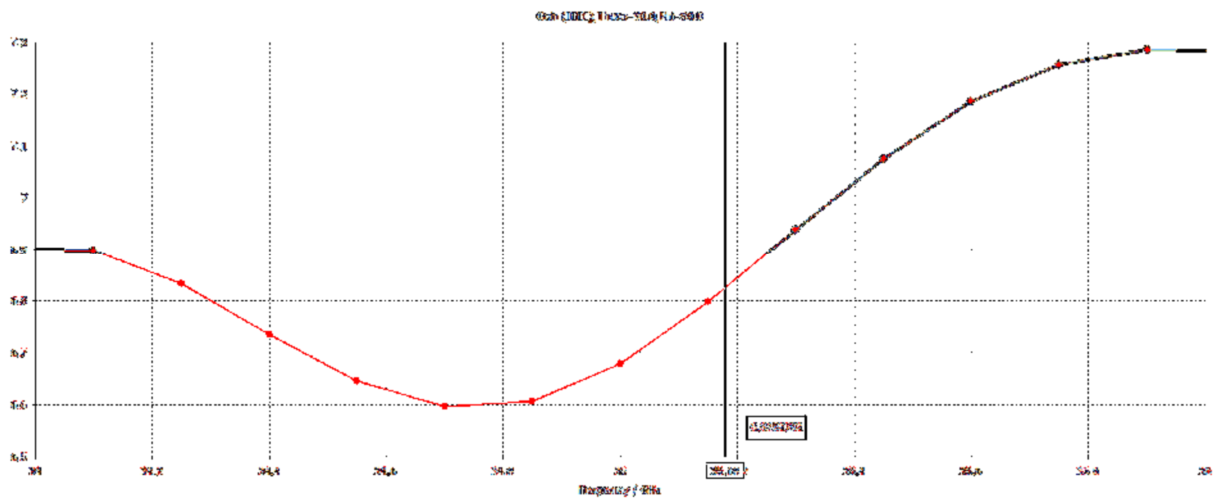

Figure 5. Gain graph from CST

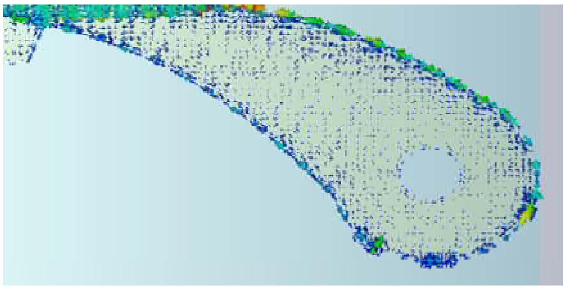

Figure 6. Surface currents

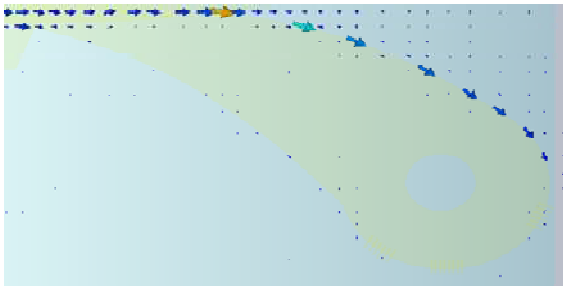

Figure 7. Power flow

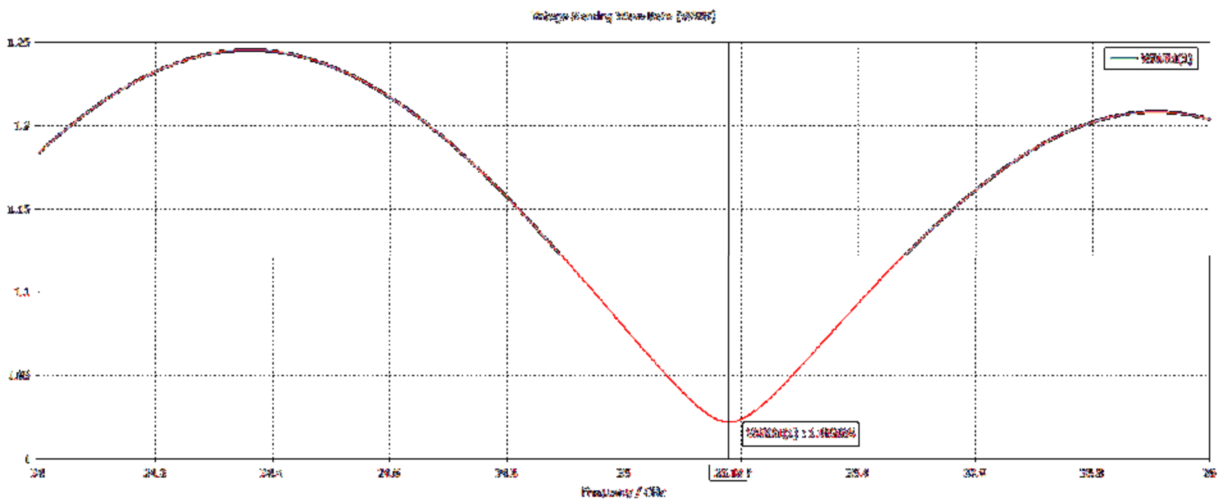

Figure 8. VSWR graph

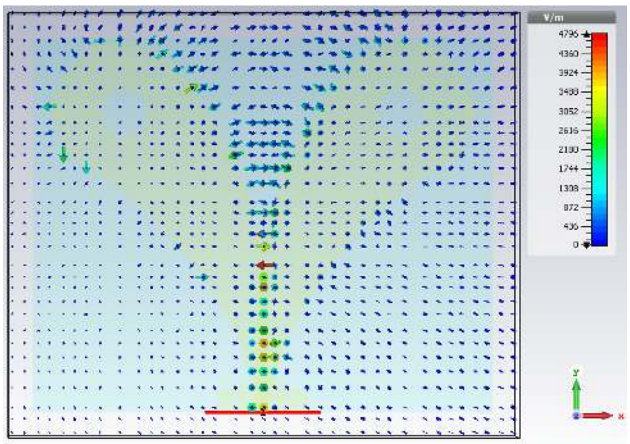

Figure 9. Electric field distribution

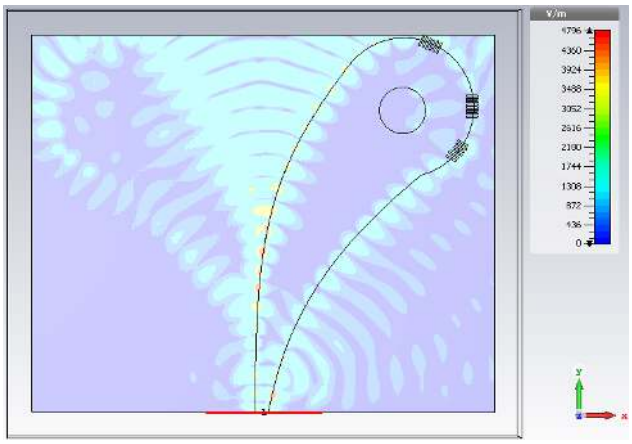

Figure 10. Electric field distribution (Abs)

## 4. RESULTS

PMI Technology consists of several important parts. Antenna is one of these significant parts. In this design, Antipodal Vivaldi Antenna is projected according to the input reflection coefficient, S11, 50 ohm impedance (Z) matching, gain (G), surface current, power flow, voltage standing wave ratio (VSWR), electric field, etc. for 35 GHz frequency window for passive imaging. The exact operating frequency is 35.18 GHz and the antenna can work between 35.12 GHz and 35.23 GHz frequencies. Consequently, the bandwidth is 110 MHz. Now, it is ready to connect the Antipodal Vivaldi Antenna to the other circuits like low noise amplifier (LNA), mixer or detector. Finally, the integrated circuits will be connected to the scanning platform which can scan azimuth and elevation axes, and the all system (scanning platform and radiometer with antenna) will be named as PMI System. At the end, PMI System will be formed and ready to view the scene in haze, foggy air conditions and it will find the hidden things under different type of clothes. Moreover, the back side of the wall.

## ACKNOWLEDGMENTS

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