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Design of a Robot Head Shaped Microstrip Patch Antennas for Multi-band Applications

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Abstract

In this paper, two different types of robot head shaped patch antennas are proposed and a comparative study is presented. Both the proposed antennas have same dimensions except at the mouth position. These antennas are fed by coaxial feeding technique and are etched on an FR-4 substrate with relative permittivity 4.4. The proposed antennas produce multiple bands resonating at 1.63 GHz, 5 GHz, 6.13 GHz, 6.91 GHz and 9.5 GHz frequencies with excellent return loss characteristics. These frequencies have applications in wireless, satellite, radar and mobile communications.

Keywords: *Robot Head shaped, Microstrip Patch, Coaxial feed, Return loss*

1. Introduction

In the last few years, a large technological jump has taken place in the field of wireless communications. Hence, the design of of antennas to meet the current high speed wireless applications is required. Microstrip antennas fulfill most of the wireless system requirements such as Bluetooth, Wi-Fi, WLAN, WiMax applications.

Microstrip antenna was introduced in early 1970's and it is a great revolution in the field of antenna design. These antennas provide various features such as comfortability and compatibility. These antennas are reliable and robust in nature [1]. These offer many advantages such as low profile, the ease of fabrication, and the low cost. In many cases, where the antenna size is considered an important limitation, their large physical size, make them improper to be used in many applications. Several methods have been considered to reduce the antenna size such as the use of shorting posts [2], material loading and geometry optimization [3].

The patch antennas are rapidly used in various fields like space technology, aircrafts, missiles, GPS, mobile communication, broadcasting etc.. But these antennas generally have a small bandwidth, which is of the order of a few percent of the operational frequency. In narrow band applications, patch antennas are very much useful. Narrow band antennas are usually designed for operation at specific frequency. Dish antennas, dipole, loop, yagi-uda antennas are some of the examples of narrow band antennas. Multiband patch antennas are investigated because of coverage of many wireless communication services such as GSM, DCS, CDMA and PCS [4, 5].

In this paper, we designed a robot head shaped microstrip patch antennas with rectangular (Antenna1) and circular (Antenna2) slot at the mouth position [6]. The antenna1 produces multiple bands resonating at 1.63 GHz, 5 GHz, 6.13 GHz and 6.91 GHz with excellent return loss whereas the antenna2 produces a band more resonating at 9.5 GHz, along with the above bands with similar resonating frequencies. The obtained frequencies cover L, C and X bands which have many applications in wireless, satellite, radar and mobile communications [7-9].

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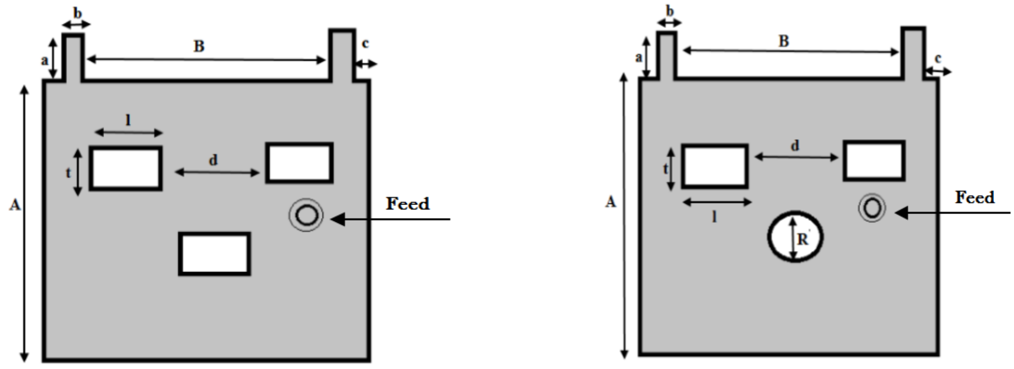
2. Antenna Design

In this design, microstrip patch antenna is used due to its light weight, thin size and patch can be of any shape. Each of the antennas consists of a patch with finite ground plane. The structure of the robot head shaped patch antennas with rectangular and circular slot are shown in Figure 1 (a) & 1 (b) respectively.



(a) Antenna1 **(b) Antenna2**

Figure 1. Robot Head Shaped Patch Antenna with (a) Rectangular Mouth Slot (b) Circular Mouth Slot

Parameter & Symbol	Dimensions(mm)
Patch length(A)	35
Patch width(B)	32
Slot height(a)	8
Slot thickness(b)	2
Slot Space(c)	2
Slot length(l)	10
Slot thickness(t)	5
Slot distance(d)	10
Circle Radius (R)	5
Feed Inner conductor radius for Antenna 1 & 2 (r)	1.2
Feed Outer conductor radius Antenna 1 & 2 (R)	2.5

The antenna is etched on an FR-4 substrate with 60 mm x 60 mm size having a relative permittivity of 4.4 and thickness of 3.4 mm. A rectangular patch is placed on the substrate which has a dimension of 35 mm x 40 mm with two rectangular slots (5mm x 10 mm) as eyes. Two small rectangular patches (8 mm x 2 mm) are united with the main patch to form the shape of a robot head. After that, a rectangular slot (5 mm x 10 mm) is made at the mouth position of the patch to form antenna1. The rectangular slot is replaced by a circular slot of radius 5 mm to achieve the desired antenna2. Both the antennas are fed by coaxial feeding technique and having ground plane with dimension same as that of the substrate.

3. Results

For the antenna1, we have obtained multiple bands of frequencies resonating at 1.63 GHz, 5 GHz, 6.13 GHz and 6.91 GHz. These frequency bands are obtained with good return loss characteristics. By replacing the rectangular slot with circular slot at the mouth position, the antenna2 produces one more band resonating at 9.5 GHz, along with the above bands with similar resonant frequencies such as 1.6 GHz, 5 GHz, 6.1 GHz, 7 GHz. The resonant frequencies which are obtained for antenna2 exhibit excellent return loss of < -20dB and cover L, C and X bands.

These frequency bands are used for Mobile Broadband Wireless Access (MBWA), Global Navigation Satellite Systems (GNSS), Global Positioning System (GPS) and the Russian GLONASS at 1.6 GHz, WLAN and Wi-MAX applications at 5 GHz, communication satellites for their uplinks at 6.1 GHz and military applications at 7 and 9.5 GHz. Thus these frequencies have applications in wireless, satellite, radar and mobile communications.

For these antenna1 & antenna2, the return loss is shown in Figure 2 (a) & (b).

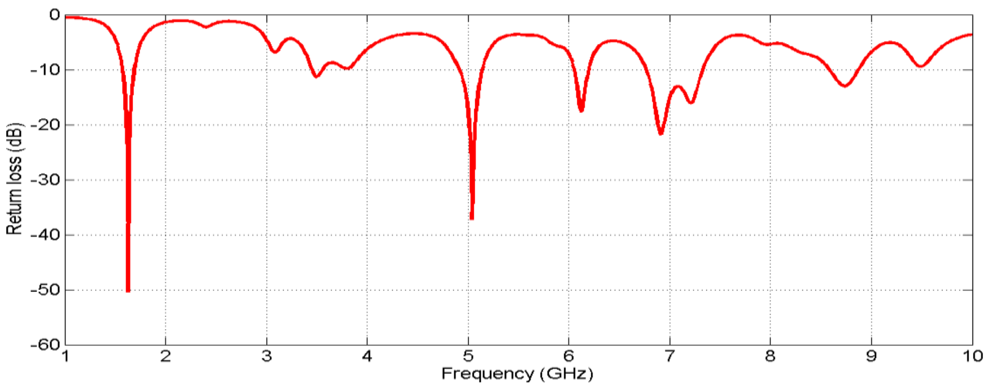


Figure 2 (a). Return Loss of the Antenna1

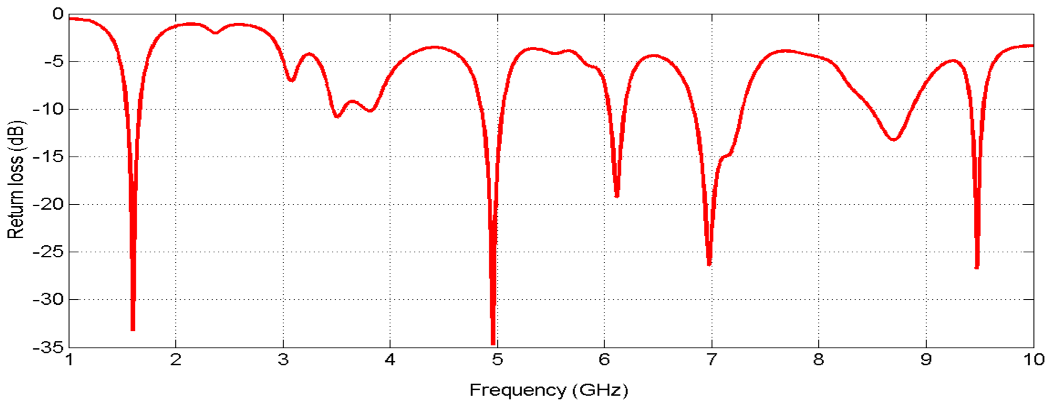


Figure 2 (b). Return Loss of the Antenna2

From the observed results it is evident that the antennas produces multiple bands of frequencies with better return loss which is < -10 dB, which gives good impedance matching for the antenna.

The VSWR plot of the antennas is shown in Figure 3 (a) & (b). The plot gives the desired values of VSWR (Voltage Standing Wave Ratio) at the resonant frequencies less than 2.

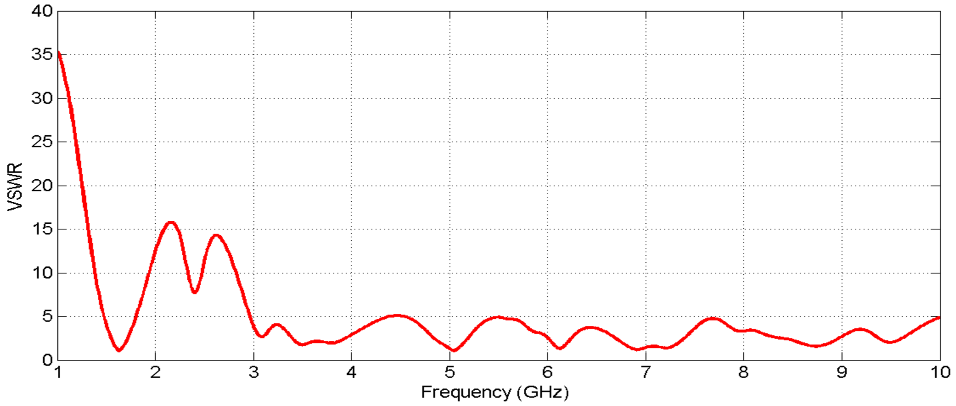


Figure 3 (a). VSWR Plot of the Antenna1

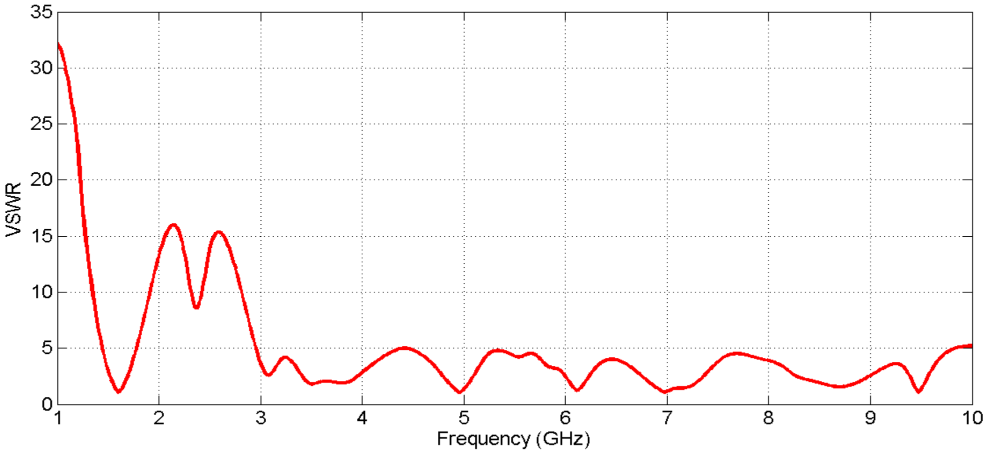
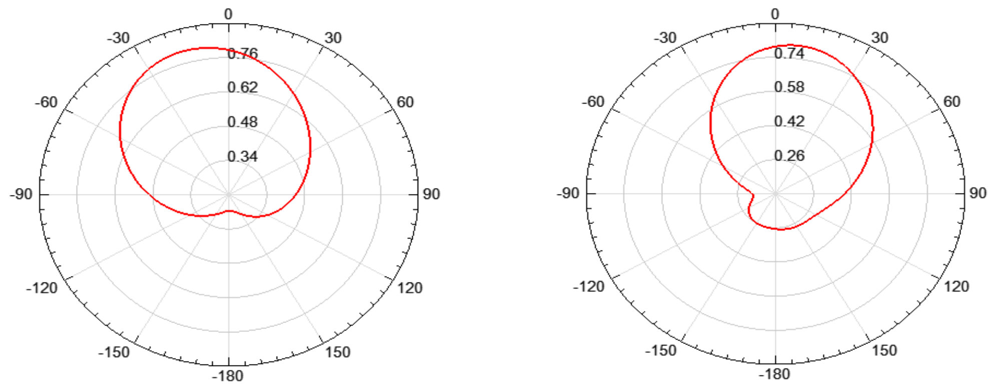


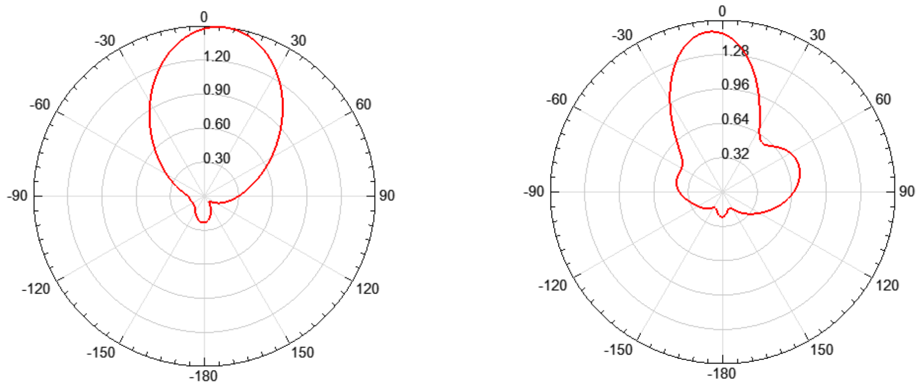
Figure 3 (b). VSWR Plot of the Antenna2

The radiation pattern of the antenna1 & antenna2 at each resonant frequency is shown in Figure 4 and Figure 5 respectively.

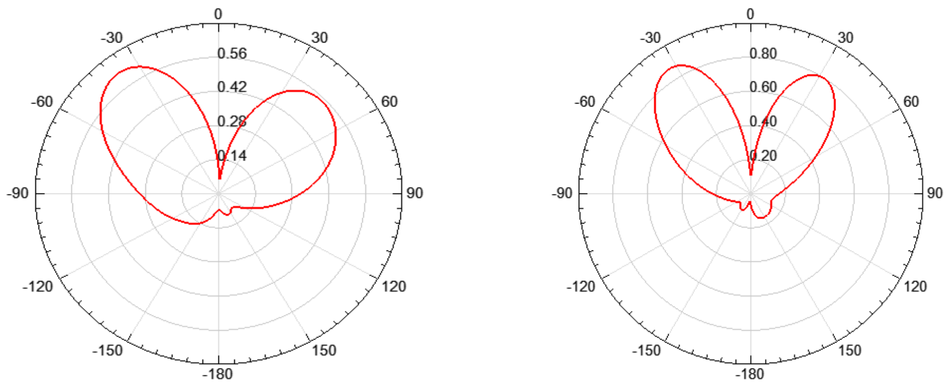


(a) E-Plane at 1.63 GHz

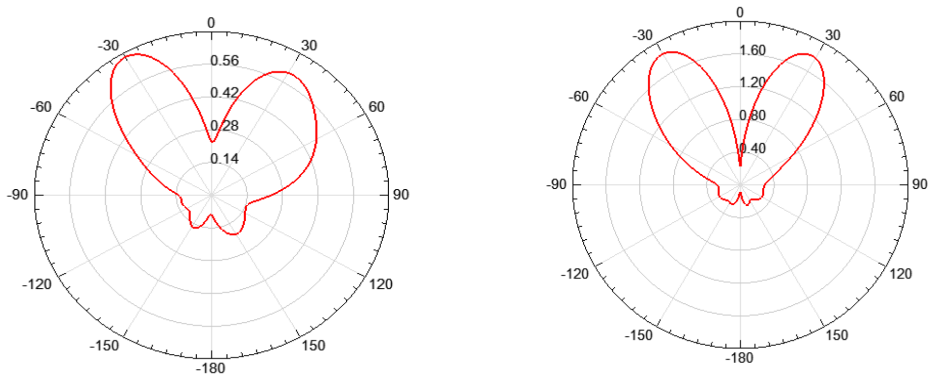
(b) H-Plane at 1.63 GHz



(c) E-Plane at 5 GHz (d) H-Plane at 5 GHz

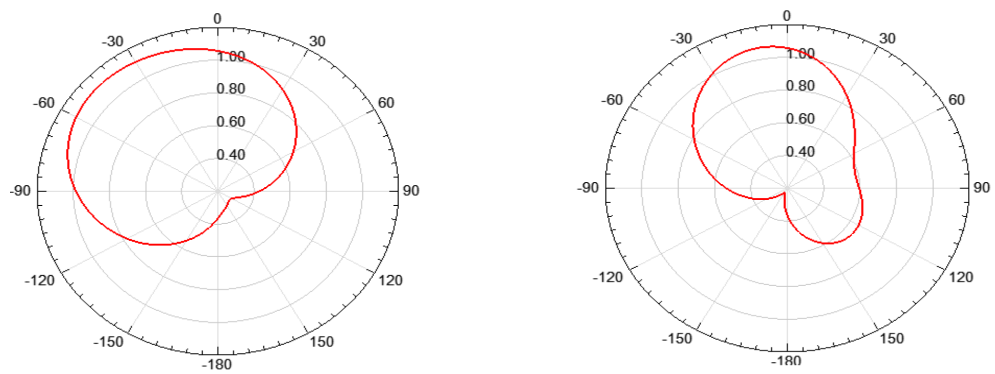


(e) E-Plane at 6.13 GHz (f) H-Plane at 6.13 GHz

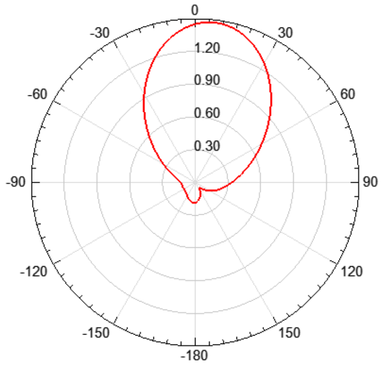


(g) E-Plane at 6.91 GHz (h) H-Plane at 6.91 GHz

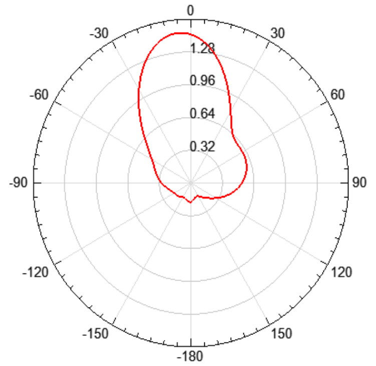
Figure 4. Radiation Patterns of the Antenna1



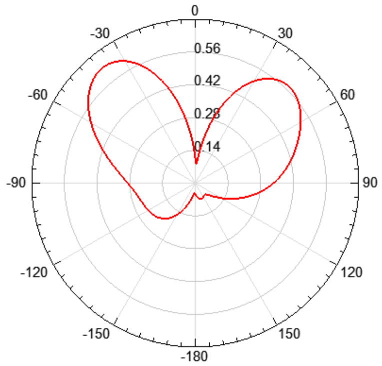
(a) E-Plane at 1.6 GHz (b) H-Plane at 1.6 GHz



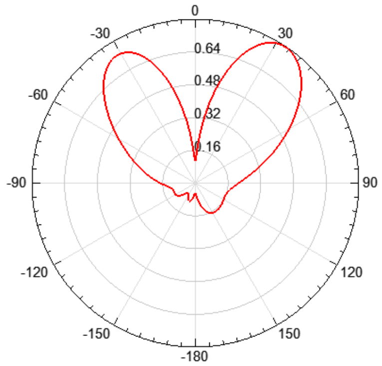
(c) E-Plane at 5 GHz



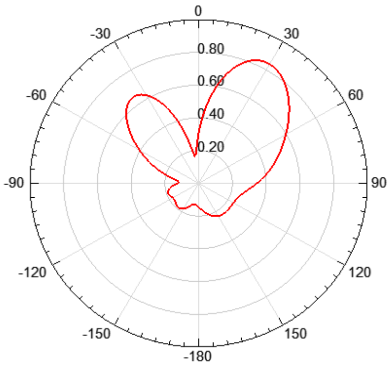
(d) H-Plane at 5 GHz



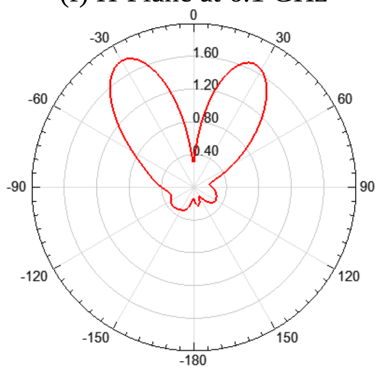
(e) E-Plane at 6.1 GHz



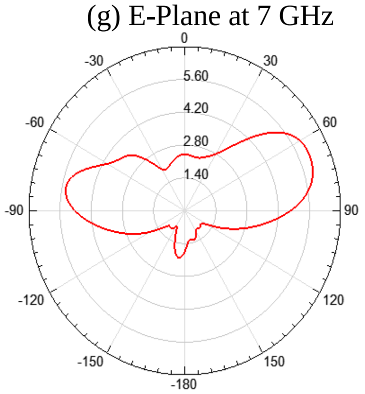
(f) H-Plane at 6.1 GHz



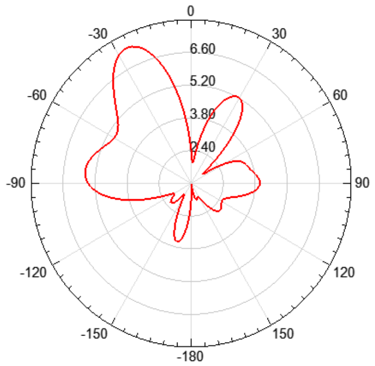
(g) E-Plane at 7 GHz



(h) H-Plane at 7 GHz



(i) E-Plane at 9.5 GHz



(j) H-Plane at 9.5 GHz

Figure 5. Radiation Patterns of the Antenna2

4. Conclusion

In this paper, we have proposed robot head shaped microstrip patch antennas with rectangular and circular slot at the mouth position resonating at 1.6 GHz, 5 GHz, 6.1 GHz, 7 GHz, 9.5 GHz with good return loss characteristics. The obtained frequencies cover L, C and X bands which are well suited for wireless, satellite, radar and mobile communications.

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