Miniaturized Slotted Patch Antenna for X-Band Apllications

S. Janani Jayasree
PG student-M.E
Department of Electronics and Communication Engineering
Sri Venkateswara College of Engineering

S. Saravanan
Assistant Professor
Department of Electronics and Communication Engineering
Sri Venkateswara College of Engineering

***Abstract*—Microstrip patch antennas are commonly used for radar communications. This design deals with the plus shaped slot in the patch and the ground plane. The slot is added in the ground and patch to improve the performance of the antenna. A square patch is added in the center of the plus shaped slot. The bandwidth of the antenna is improved by 200MHz and is being operated at dual bands (10.1GHz and 11.7GHz operating frequency) using CST Microwave Studio. This proposed antenna is used for Military Radar applications**

***Index Terms*—Microstrip Antennas, Rectangular ground plane slot antennas, X-band and CST Microwave studio.**

I. INTRODUCTION

Printed antennas which are used at microwave frequencies are becoming very popular and important considerations due to their low-cost, profile and ease of fabrication. Most printed antenna which is operated in single frequency can be conformed on any curved surface and has narrow bandwidth [1]. Printed antennas are usually used at UHF and higher frequencies and have high accuracy in manufacturing. The size of the antenna is proportional to its wavelength. The ground plane is made of high conductivity metal (copper). Many substrates like Fr4, RT Duroid, Bakellite etc. are used as a substrate material [2].The proposed antenna deals with FR4 which is very popular, versatile and has 0.013% tangent loss. It has good mechanical strength. The dielectric constant of the substrate is 4.36, but the performance is improved in terms of bandwidth and return loss [3-6]. Dielectric constant affects the antenna performance. An increase in the thickness of the substrate will considerably reduce conductor loss and improves the bandwidth. Many popular feeding structures like microstrip, coaxial, aperture coupled and proximity feedings are being used [7-10]. But this proposed antenna uses microstrip feed line because of its impedance matching with better radiation pattern and even improves bandwidth [11-12].

At the X-band, the microstrip feed line is proposed. This plus shaped slotted patch antenna is mainly used in the radiolocation especially in radar systems and wireless applications. Radars are mainly used to detect ships, spacecrafts and many space borne applications. Modern uses of radar are varied, including military, marine radar, ocean surveillance etc.

II. SLOTTED PATCH ANTENNA DESIGN

The proposed work deals with a microstrip patch antenna with a plus shaped slot in the patch as well as in the ground plane which is shown in fig 1 and 2. The dimension of the patch and slot is 30.8×20mm and 2.56×7.3mm. The radiating element is placed on the grounded dielectric substrate with relative dielectric constant. Major consideration is the gain, directivity, VSWR and return loss. The feed line used is microstrip line and it should match 50Ω impedance. The ground plane is copper and the substrate is FR4, which is more versatile. The height of the substrate is taken as 1.6mm. The radiating patch is resonant and the patch should match with the input impedance. For matching, half wave transmission line is used between the patch and substrate. A single port is fed at the beginning of the patch and the port used for this design is the waveguide port. The vertical slot and horizontal slot is added in the ground plane to improve the bandwidth. The intersection of the two slots contains a small square patch. The resonance of the design is proportional to the dimensions of the slot. The software used for this design is CST Microwave suite. The printed slot antenna is operating at 10.1GHz and 11.7GHz.

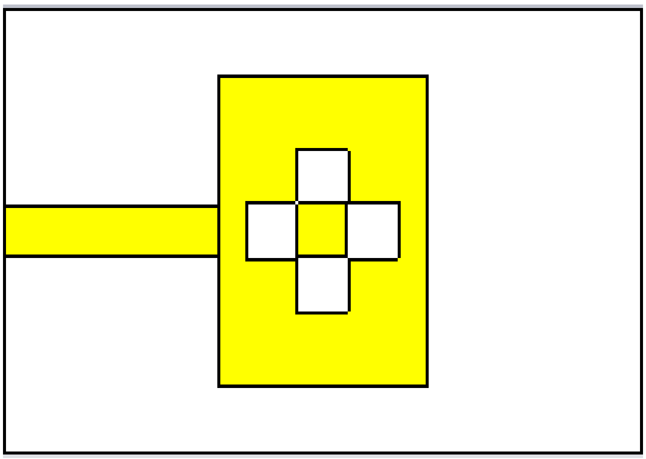

Fig 1. Front view of slotted patch antenna

The front view of the slotted patch antenna is illustrated in fig 1. The slotted patch antenna is designed using CST Studio. In Fig 2 the slot with the nickel as a material is added in the ground plane to improve bandwidth. The microstrip line feed is one of the easiest methods amongst the feeding techniques. Microstrip line is a transmission line connecting the patch and port. Modeling the microstrip line is simple. Matching is done by using the quarter wavelength transmission line. Substrate thickness increases with spurious feed radiation, which is the major disadvantage. As the thickness of the substrate increases, the bandwidth and directivity of the antenna improves. This drawback limits the bandwidth of the slotted patch antenna. The design considerations of slotted patch antenna are given by

- Substrate-FR4
- Ground plane-Copper(annealed)
- Patch- Copper(annealed)
- Slot-Nickel

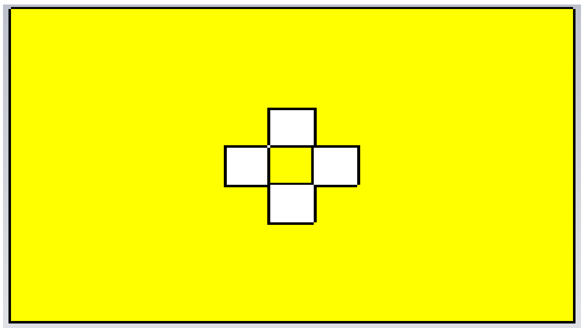

Fig 2 : Back view of the slotted patch antenna

III. RESULTS AND DISCUSSION

In this section, detailed simulated results of the proposed slotted patch antenna are presented. In the first part we discuss about the reflection coefficient of the slot-patch array antenna. The S11 parameter has an operating frequency of 10.1GHz and 11.7GHz. S-parameter or reflection coefficient is the elements of the scattering matrix. S-parameters are frequency description with complex numbers expressed in terms of magnitude and phase. VSWR should be less than or equal to 2. The reflection coefficient of the slot–printed antenna operating at 10.1GHz and 11.7GHz is shown in fig 2 and the bandwidth obtained is between 10.406GHz and 9.8253dB. The slotted patch antenna has a bandwidth of 600MHz.

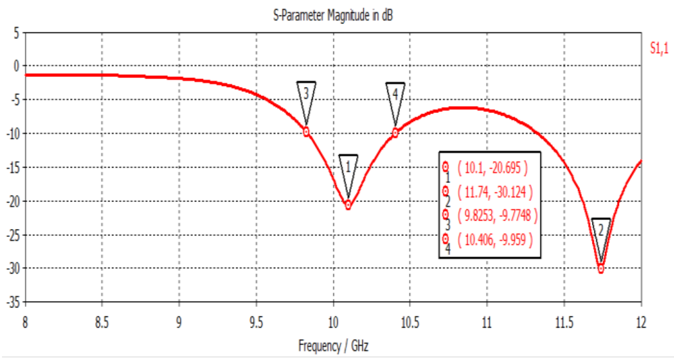

Fig. 3. Reflection coefficient of slot-printed array antenna

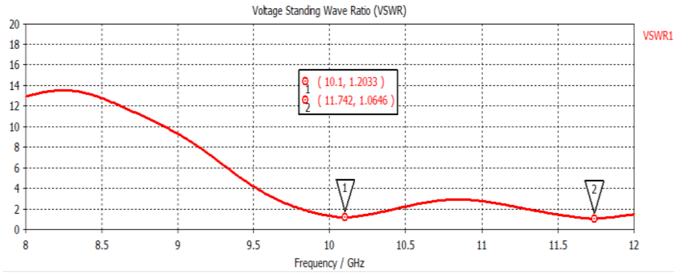

Fig. 4: VSWR plot of slotted patch antenna

The VSWR plot of the slot-printed antenna shown in fig 4. Here the value of VSWR for two bands is 1.2033 and 1.0646.The angular width and main lobe magnitude is 73.4deg and 13.7dB. Fairfield gain phi is 0.

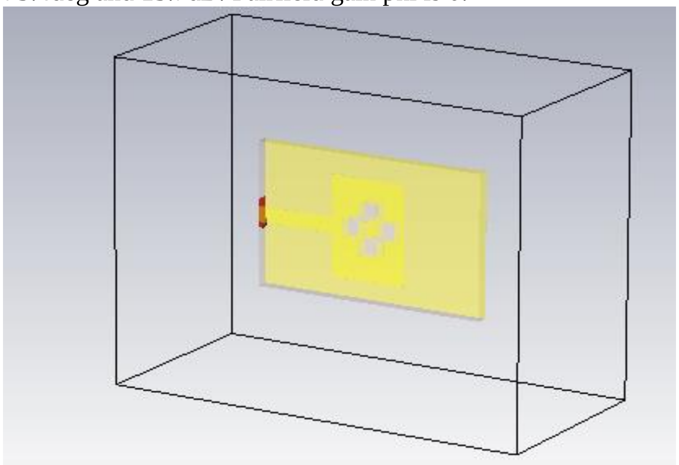

Fig 5: Waveguide port of slotted patch antenna

Fig 5 shows the waveguide port of slotted patch antenna. Fig 6 shows the 3D pattern of slot-printed array antenna with gain 4.45dB. The directivity is 14.07dBi, which is shown in fig 7. Directivity is an essential parameter for an antenna. Directivity is a component of gain and it measures the radiation pattern of an antenna. Directivity of this proposed antenna is 6.43dBi. The gain of the antenna is 4.7dB.The 3D pattern of this proposed dual band slotted patch antenna shows the bidirectional pattern. In fig 6, the red region represents area with maximum radiation.

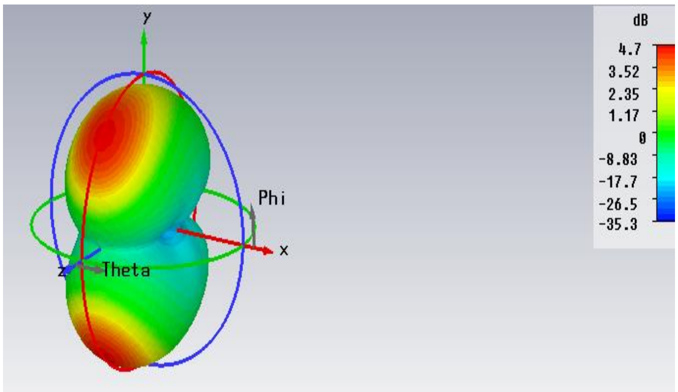

Fig. 6. Gain of the slot-printed array antenna

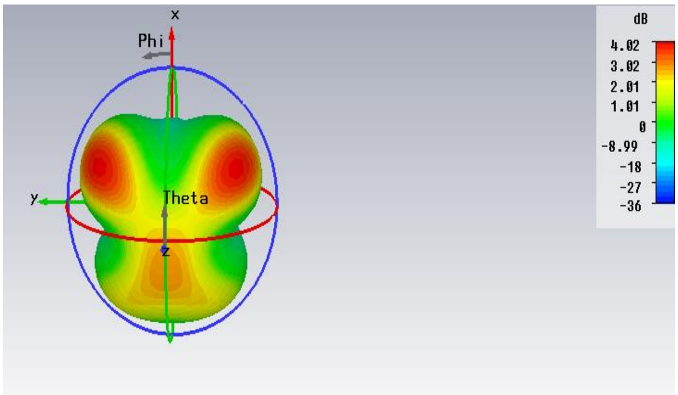

Fig 7. Gain of slotted patch antenna

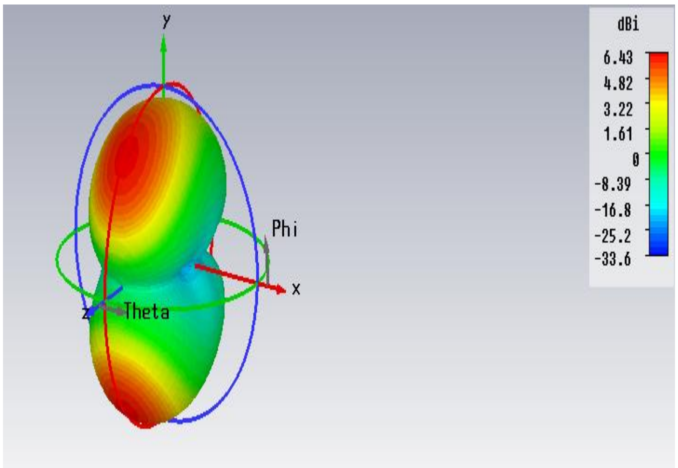

Fig 8 . Directivity of slotted patch antenna

This slotted patch antenna is being operated at dual bands i.e. 10.1GHz and 11.7GHz .Proposed antenna is mainly used for Military Radar applications. Military radars are used to measure the distance between the ships and to prevent collision with other ships. It helps to navigate and fix their position at sea when within range of shore or other fixed references such as islands, buoys, and lightships. Vessel traffic service radar systems are used to monitor the ship’s movement at sea.

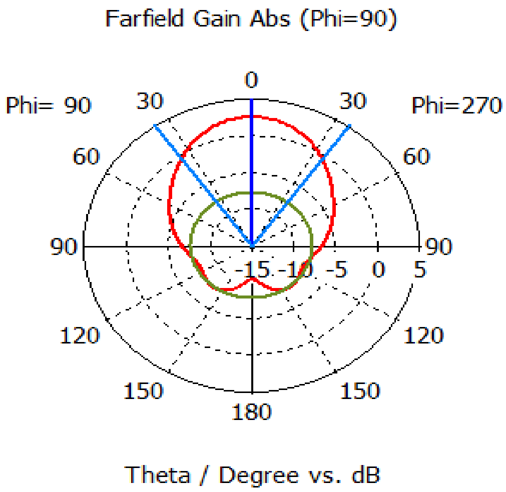

Fig 8: Directivity of proposed antenna for 11.7GHz in polar plot

IV. CONCLUSION

Patch antenna has a major disadvantage of narrow bandwidth. In this paper, the slot is added in the patch and ground plane to overcome the difficulty of bandwidth. Proposed antenna is designed for dual band applications and it is being operated in X-band (8-12GHz) applications. Proposed slotted patch antenna has major advantages like light weight and small size, which is a major criteria for radar systems. Since the size is very small, the antenna is applicable for handheld portable devices. The operating frequencies are 10.1GHz and 11.7GHz, which is especially used for Military radars for monitoring, navigation and to fix positions on the sea shore. The return loss of the proposed antenna is -20dB and -30dB. Simulated results of gain, directivity, VSWR and return loss for dual bands 10.1GHz and 11.7GHz are presented. Thus the performance parameters like gain, directivity, VSWR and return loss are improved due to slots in both ground plane and patch.

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