High Gain Aperture Coupled Patch Antenna

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***Abstract*— This paper is intended to build a High Gain Aperture Coupled Micro-Strip Patch Antenna to improve its radiation performance. The proposed design is based on a new aperture coupling technique in which the slot is fed by a micro strip line coupled to the patch radiators. The patches are employed to reduce the radiation into the half-space that they occupy and increase the radiation in the other half-space. The shape of the patch used is very much responsible for the radiation pattern in the desired direction. Radiation characteristics and bandwidth are also improved by choosing a suitable combination of the shape of feed and slot. Due to this aperture coupling between patch and micro strip slot line, we achieve both improvement in radiation pattern and bandwidth. We achieved 0.563GHz of 10 dB bandwidth at 3.6 GHz resonant frequency. This design was simulated using HFSS (High Frequency Structure Simulator).**

***Keywords*- Aperture coupled, patches, slot, feed line.**

I INTRODUCTION

MICROSTRIP patch antennas (patch antennas excited by a strip line) have been extensively used in military (aircraft, spacecraft, satellites, and missiles) and commercial (mobile radio and wireless communication systems) applications [1]. These types of patch antennas have numerous promising features, for instance, they have light weight, small size, and low cost. In addition, they can be easily integrated with planar and non planar surfaces and have many degrees of freedom in their design. However, they have significant radiation in some undesired directions which lead to power loss and significant back lobes lead to electromagnetic energy exposure for mobile phone users in case of mobile phones. The radiation pattern is very important parameter in antenna design if the specific absorption rate (SAR) is considered [2]. Aperture coupling is an indirect method of feeding the resonant patch. It couples the patch with micro strip line through an aperture or the energy of the strip line and it is done via the opening (slot) in the ground plane which excites the patch. This aperture is usually centered with respect to the patch where there is maximum magnetic field. For maximum coupling it has been suggested that a rectangular slot parallel to the two radiating edges should be used [6]. Two very similar coupling mechanisms take place, one between the feed line and the slot and another between the slot and the patch. Dielectric constant of the substrate used for the feed should be in the range of 2 to 10. A thinner feed substrate results in less spurious radiation from feed lines but higher loss. Feed line width decides the characteristic impedance of the feed line [3].

There are two approaches: 1) simulation and measurement of radiation patterns and 2) observation of standing wave distributions. For the above purposes, a cell structure is first considered. As shown in Figure. 1, this cell structure consists of one slot and two patches.

According to the operating mechanism described, the spacing between the two patches and the thickness h of the substrate are very significant in affecting the antenna performance.

II DESIGN & SIMULATION

For designing high gain patch antenna, we used a micro strip line on Roger RT/Duroid5880 substrate of permittivity of 2.2 and loss tangent of 0.0009 with size E=40x40 mm^2 and dielectric thickness of h=0.76 mm and

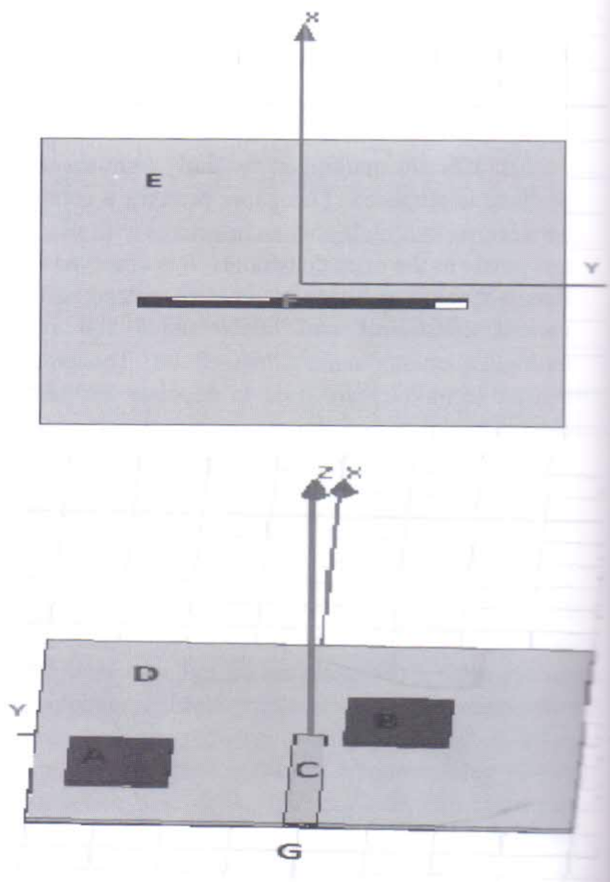

Fig.1 Geometry of the proposed patch antenna: (a) Top view (b) Bottom view

metal thickness is t=0.024mm and size D=40x40mm^{2}and the width of strip is 2.3mm and length 20 mm and the patches have length of 7.5mm and width of 10mm. Slot line has the length of 25mm and width 1.5 mm. cut from the ground.

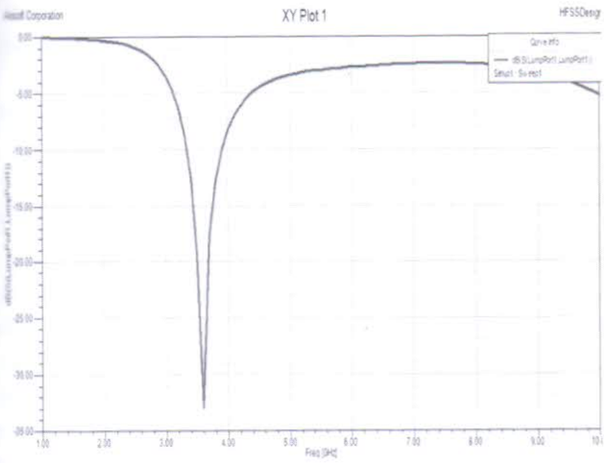

Fig. 2 Simulated Return loss

III RESULTS & OBSERVATION

For the study described in this paper, the antenna is expected to operate within a frequency 5.0 GHz. The effective length of the slot line is approximately 25mm so that the peak voltage will be located at the center of the slot. The influence of the thickness on the return loss is shown in Figure. 2. Thickness of slot is 1.5 mm, the antenna resonates at 3.6GHz and the corresponding return loss is 34 dB and bandwidth is 3.893-3.330=0.563GHz. From the figure3 Peak Directivity is 94.955 and Peak Gain is 93.841. In proposed structure decay factor is zero and F/B Ratio is 1.919 from Figure 4.

The radiation efficiency is 0.98827. The resonant frequency dependence of the thickness is very similar to that of the position of the patches. These results are due to the fact that the thickness affects the coupling among the slots, the feed line, and the patches. Figure 4 shows the radiation pattern. Summarizing the effects of the two parameters, it is found that the spacing affects the front and back radiation of the proposed slot antenna but the thickness mainly affects its back lobes when the spacing is set. This phenomenon is due to the fact that the spacing mainly affects the standing wave distribution, whereas the thickness mainly affects the couplings between the slot and the patches. The VSWR in figure5 is 1.06 at 3.6 GHz resonant frequency. The former offers different front–back radiation ratios, whereas the latter results in different shorting characteristics [4]. This result is fully consistent with the described mechanism given in Section II. In addition, we can observe in the proposed design example that the optimized values for the spacing and the substrate thickness should be 20 and 2.3 mm respectively.

IV CONCLUSIONS

This paper has demonstrated by simulations and experiments a new aperture coupling structure for micro

Antenna Parameters

Inputs

Setup Name:	Infinite Sphere1
Intrinsic Variation:	Freq='5GHz'
Solution:	LastAdaptive
Design Variation:	N/A
Array Setup:	Regular Array

Antenna Parameters:

Quantity	Value	Units
Max U	406.88	W/sr
Peak Directivity	94.955	
Peak Gain	93.841	
Peak Realized Gain	51.131	
Radiated Power	53.847	W
Accepted Power	54.487	W
Incident Power	100	W
Radiation Efficiency	0.98827	
Front to Back Ratio	1.#INF	
Decay Factor	0	

Fig. 3 Antenna parameters

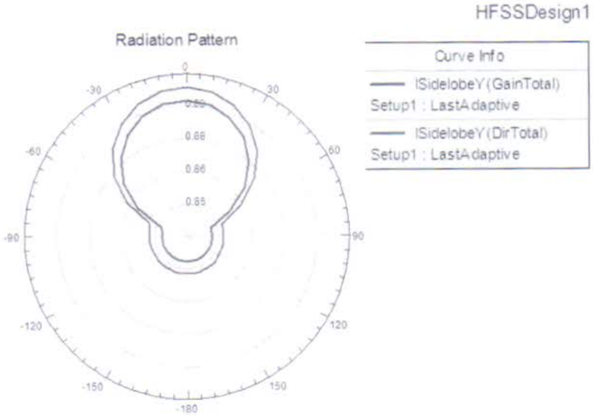

Fig.4 Radiation pattern (gain & directivity)

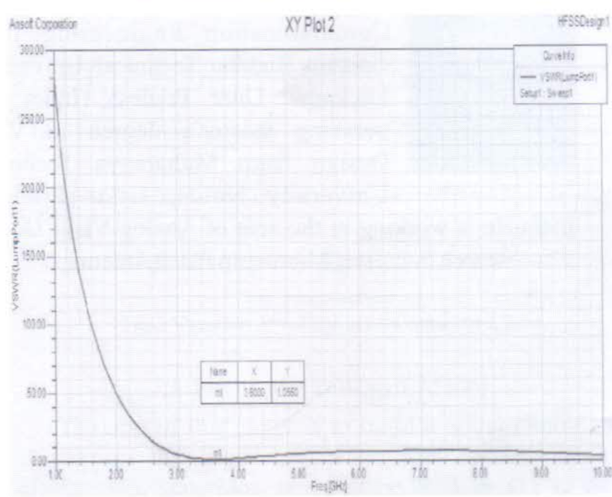

Fig. 5 VSWR

strip patch antenna. The new design utilizes two parasitic patches on the opposite side and along the axis of the slot. This arrangement establishes the aperture electric field in the slot with standing wave distributions approximately in phase on the same side of the slot but approximately out of phase in the opposite side. Therefore, a patch antenna can radiate unidirectional with a high front–back radiation ratio without using a back cavity or reflecting plate. The main beam can be set in the desired direction such as in the broadside direction independent of a slot length. Most importantly, as the electrical length of the slot is increased, the radiation strength in the main beam is also increased but the side lobe level is reduced. These promising features allow the proposed micro strip slot antennas to offer good potential for high gain and low radiation power loss applications. Additionally, due to the use of a single dielectric layer, the proposed design, compared to a back plate or cavity, can also offer advantages in terms of light weight, low profile, and compact size.

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