

Slot Antenna for frequency Switchable Active Antenna

Harish Kumar[@] Member IEEE, V K Sharma[@], Navdeep Singh[#] Student Member IEEE, Sarabjeet Singh[#]

[@] Deptt of E.C.E, Bhagwant Institute of Technology, Muzaffarnagar, India

[#] Department of Physics, Dr B R Ambedkar National Institute of Technology, Jalandhar, Punjab, India.

hc78@rediffmail.com , arora_navdeep@yahoo.com

Abstract—Annular slot antenna having dual port and dual band which is suitable for use in the feed-back path of an oscillator resulting in an active antenna configuration by using the modern MIC and MMIC fabrication technology, compact light weight, and low cost active antenna are realized. The proposed antenna is designed to radiate and transmit equal amounts of power. The return loss of the proposed antenna is higher than that desired for one-port antenna application at the desired dual-band frequencies. The antenna is fabricated on one side of a Neltec substrate ($\epsilon_r = 3.3$ and thickness = 0.762 mm) and the microstrip feeding line is fabricated on the opposite side of the board. The antenna was designed to operate at WLAN bands centered at 2.4 and 5.2GHz. The simulated and measured results show fairly good agreement. The measured return losses were found 20.5 dB at 2.4 GHz and 13.9 dB at 5.2GHz while simulated return losses were 9.36 dB at 2.4 GHz and 31.35 dB at 5.2 GHz. The radiation pattern is approximately omnidirectional at both frequencies in H-plane.

Index Terms — Two Port Antenna, Active Antenna, Dual Frequency Antenna.

I. INTRODUCTION

While the terminology of active antenna means that active devices are employed in passive antenna element improve performance. Active integrated Antenna (AIA) having a passive structure i.e. micro strip antenna and active devices (diode such as Gunn, IMPATT, BARITT, etc., or a transistor such as MESFET, High Electron-Mobility Transistor (HEMT), Hetero-junction Bipolar Transistor (HBT) etc) integrated together in a circuit. The idea of active antenna can be traced back in early 1928[1].

An oscillator type active antenna requires a two port antenna in the series feedback network of amplifier to behave as an oscillator. This two port antenna works as load as well as a resonator for the amplifier. For this kind of application two port antennas should be capable of both to radiate in free space and transmit to second port equal amount of power [2]. In the category of dual port antenna; T-shaped coupled structure, bull horn shape, line resonator, two dipole under tight coupling etc have been reported [3-6]. Dual band active antenna already reported in the literature using shorted pin structure, stacked structure. Dual band active antenna is useful in WLAN application.

In this paper, we describe two port dual frequency antennas by using annular slot resonator. The ground plane consist of annular slot can be considered a complementary structure to a micro strip ring. If the symmetry of the ring is disturbed, then split resonant modes are excited [7]. It is also possible to excite multiple modes in a shorted slot antenna as demonstrated in [8], where the second operating frequency was 1.8 times greater than its first operating frequency.

Antennas of this type of structure can radiate on both sides of the slot and can form an Omni-directional pattern, which may be useful for wireless communication systems. The annular slot antenna is a variation of micro strip antenna with better gain, wider bandwidth and is less sensitive to manufacturing tolerances.

A dual frequency antenna has been designed and simulation was carried out using CST microwave studio software. This antenna was fabricated using Monolithic Integrated Circuit techniques and measurement was carried out using Vector Network Analyser and the radiation pattern was measured in H plane and E plane using UWB Pyramidal horn antenna radiation pattern in anechoic chamber. The proposed theoretical results show the qualitative agreement with measured results. Application of proposed antenna as an active antenna is shown in Fig. 1

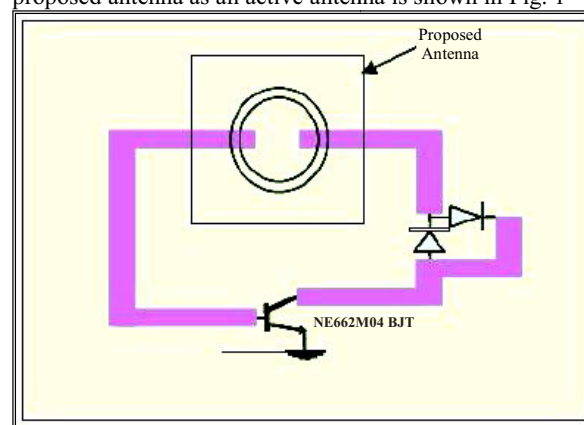


Fig. 1(a) Active antenna scheme

II. DUAL PORT ANNULAR SLOT DESIGN

The annular ground slot consists of a circular slot on a square, metal ground plane that is fed by two micro strip line fabricated on the opposite side of the substrate. The slot diameter is derived from the dependence of the field Patterns on free space wave number $K_0 = 2\pi/\lambda_0$. It is found that if the product of the radius, a and K_0 is equal to 1 or 2, then the Omni-directional pattern is obtained which is evident from the radiation pattern equation [9-10].

TABLE1. RETURN LOSS, INSERTION LOSS AND BAND WIDTH OF PROPOSED ANTENNA

Frequency (GHz)		2.4	5.2
Return Loss (dB)	Simulated	-9.36	-31.35
	Measured	-20.5	-13.9
Insertion Loss (dB)	Simulated	-1.59	-1.51
	Measured	-1.25	-3.36
Impedance BW (GHz)	Simulated	0.71	1.31
	Measured	0.45	2.05

The mean length of the slot circumference is approximately $3\lambda_s/2$ at the design frequency where λ_s is the equivalent wavelength in the slot transmission line with slot width sw . The slot width sw is much small compared to λ_s . The feed lines cross the slot and terminate in an open circuit. The length of each feed line is of the order of $\lambda_g/4$ is guided wavelength in micro strip.

At the intersection of the micro strip line and slot, magnetic coupling occurs, which due to $3\lambda_s/2$ ring circumference, creates a null in the direction of feed lines. The above equations are used to design a micro strip fed annular slot antenna. Because of two feed lines the calculated dimensions were unable to give require results. Hence both dimensions were optimized using CST Microwave studio simulator to obtain required results for dual port antenna. The CST Microwave Studio is finite integration technique based simulation software. A small gap between two feed lines provides DC blocking in the circuit. The proposed antenna was fabricated on Neltec substrate of dielectric constant $\epsilon_r = 3.2$, loss tangent $\tan\delta = 0.001$, substrate thickness $h=0.762$ mm, strip conductivity $\sigma=5.8 \times 10^{-7}$ mho/m. The mean radius of ring $R_m = 8.3$ mm, width $S_w=2$ mm, length of feed line = 24.65mm, gap between two feed lines = 1.5mm. The SMA connectors were soldered to feed the antenna from micro strip line below the annular slot, as shown in Fig. 2(a) & (b).

III. RESULTS AND DISCUSSION

A. Network Parameter Measurements

As Proposed antenna was characterized using VNA. The S parameters in Fig.3 show good agreement between measured and simulated results. The lack of fabrication accuracy is probably little bit offset in alignment of feed-line mask and ground plane mask leads to variation in simulated and measured frequencies

B. Radiation Pattern Measurement

A far field antenna test range was used to characterize the proposed antenna. In the test range, proposed antenna was used as a receiver that rotated through two orthogonal planes for 2.4 and 5.2 GHz frequencies while UWB gain horn antenna was used as standard, transmitting antenna were separated by 1.9 m. The Co and Cross polarization of the antenna for 2.4 and 5.2 GHz are shown in Fig.4. The Half-power beam width is shown in Table 1. The antenna is Omni-directional at 2.4GHz and nearly Omni-directional at 5.2 GHz in H-plane. As the proposed fabricated antenna has sufficient insertion loss to maintain the close loop gain and good return loss to radiate sufficient amount of power that fulfils the requirements for active antenna application.

IV. PARAMETRIC ANALYSIS

Three parameters were chosen for the analysis and vary one of them keeping two parameters constant at proposed design value g Gap increase in step of 0.5mm the resonance frequency increase with little bit degradation in return loss and slight change in insertion loss. As slot width increase in steep of 5mm the resonance frequency decrease no change in return loss at 2.4 GHz but little bit improvement in return loss at 5.2 GHz. The mean radius of slot is inversely proportional to the resonance frequency. The S parameters under various parameter analysis conditions have shown in Fig .5.

TABLE 2. HALF POWER BEAMWIDTH & MAXIMA OF PROPOSED ANTENNA

Frequency (GHz)	Maxima	Beam width in H Plane	Beam width in E Plane
2.4	80°	105°	55°
5.2	170°	75°	65°

V. CONCLUSION

A design of dual port dual frequency annular slot antenna was studied. The antenna was to be designed to operate at WLAN bands centered at 2.4 and 5.2 GHz, now current status of the work was presented with all results showing fairly good agreement between simulated and measured results.

This proposed antenna is well suited in oscillator type active antenna applications and domestic networks because of low profile and mass production possibility

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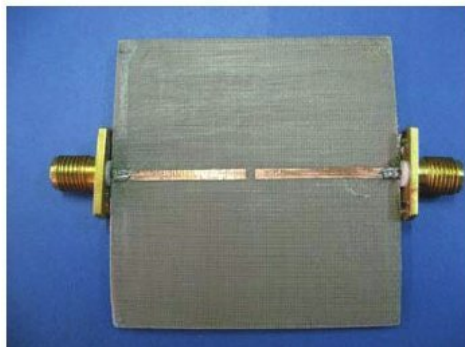


Fig. 2(a) Photo of antenna feed lines.

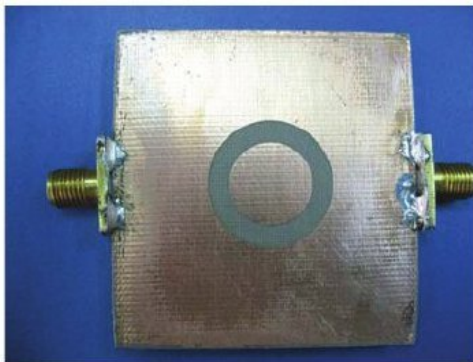


Fig. 2(b) Photo of annular ground plane

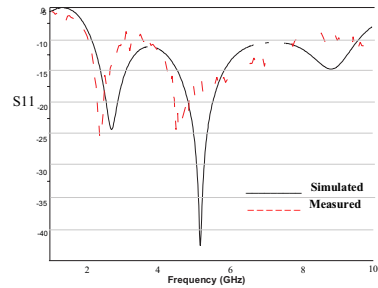


Fig. 3(a) Measured & simulated Return loss

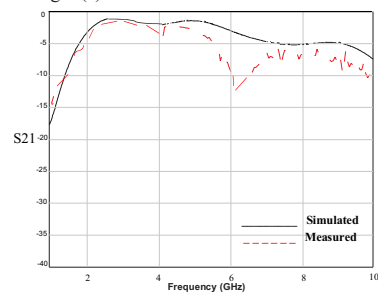


Fig. 3(b) Measured & simulated insertion loss

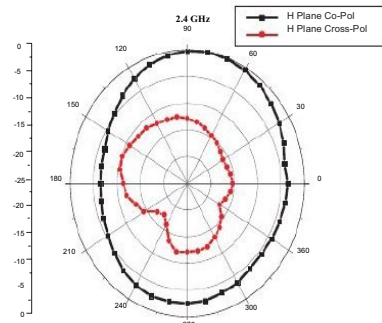


Fig. 4(a) Radiation pattern H-plane at 2.4GHz

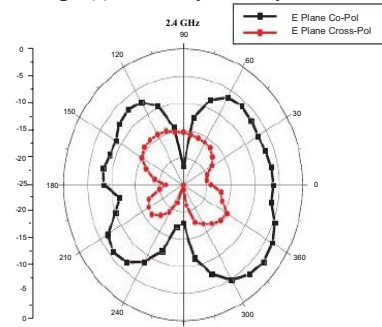


Fig. 4(b) Radiation pattern E-plane at 2.4GHz

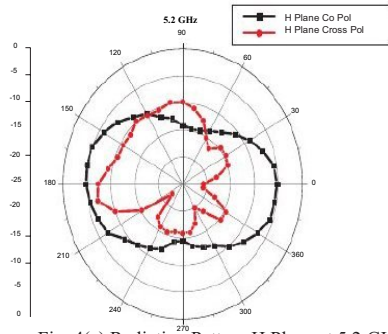


Fig. 4(c) Radiation Pattern H Plane at 5.2 GHz

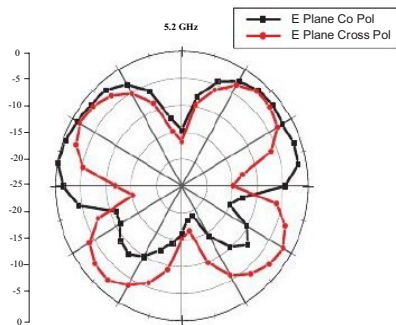


Fig. 4(d) Radiation Pattern E Plane at 5.2 GHz

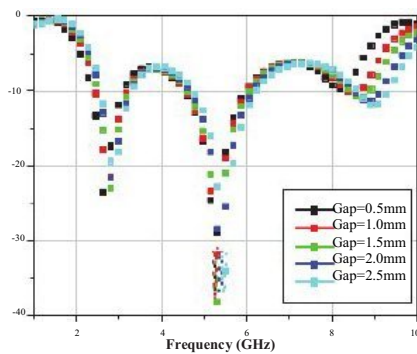


Fig. 5(a) Return Loss for Gap variation

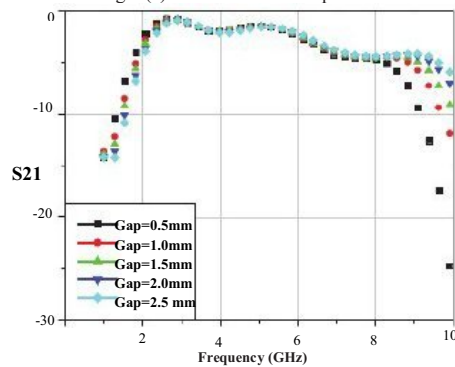


Fig. 5(b) Insertion Loss for Gap variation

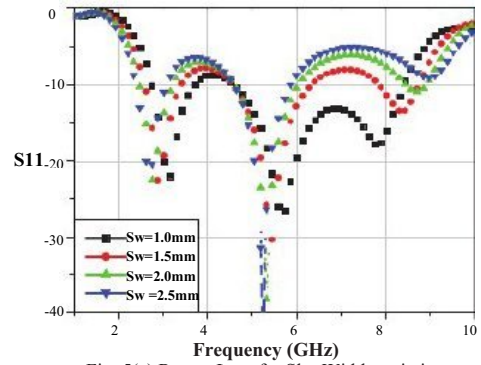


Fig. 5(c) Return Loss for Slot Width variation

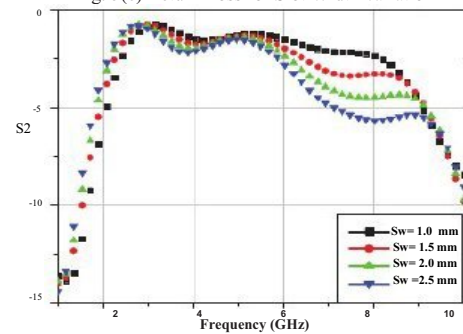


Fig. 5(d) Insertion Loss for Slot Width variation

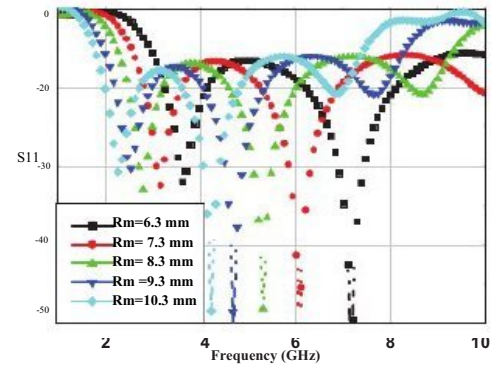


Fig. 5(e) Return Loss for mean radius variation

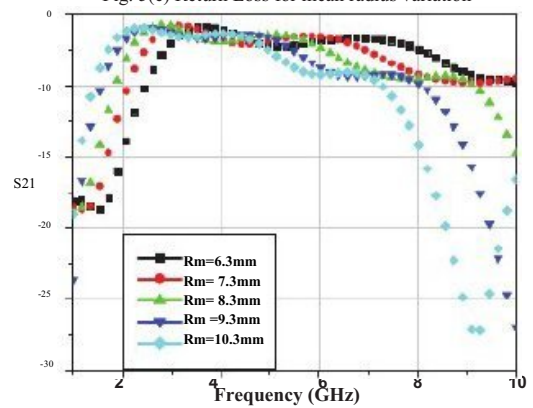


Fig. 5(f) Insertion Loss for mean radius variation