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Inclined Slot Loaded Proximity-Coupled Microstrip Antenna for WLAN

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***Abstract* -** The design of a miniaturized proximity-coupled microstrip antenna (PCMA) is presented here. The antenna has very small size, wide bandwidth and moderate gain and may be used as small, compact antenna for 5GHz band wireless local area network (WLAN). Simulated results using IE3D software are verified by measurement.

***Keywords* -** *Proximity-Coupled, Slot-Loaded, 2:1 VSWR Bandwidth, Broadside Direction.*

I. INTRODUCTION

Planar, thin, light weight antennas are attractive for wireless applications. There are various types of wireless local area network (WLAN) standards, like, Bluetooth, WiFi, WiMAX, HIgh PERformance LAN (HIPERLAN) etc. For next generation wireless networking, high speed broadband systems HIPERLAN/, HIPERLAN/2 are proposed, which uses frequency band of 5.470 GHz – 5.725 GHz. The objective is to design a broadband miniaturized planar antenna for HIPERLAN/2 with moderate gain. Here, the bandwidth is defined as the frequency range for which return loss is –10 dB or less and gain is 4 dBi or more. Here, the design and parametric studies of an inclined slot-loaded proximity-coupled microstrip antenna (PCMA) are described. Single layer Microstrip antennas have very narrow bandwidth because of their inherent properties, but using multilayered proximity coupling, higher bandwidth can be achieved. In PCMA, the radiating patch, fabricated on a dielectric substrate, is excited by a microstrip line on another substrate, as shown in Figure 1.

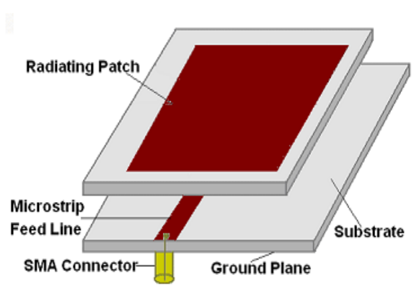

Fig. 1: Proximity-Coupled Microstrip Antenna

In wireless environment, signals are scattered from various structures and reach the receiving terminal from any unpredicted direction (Figure 2).

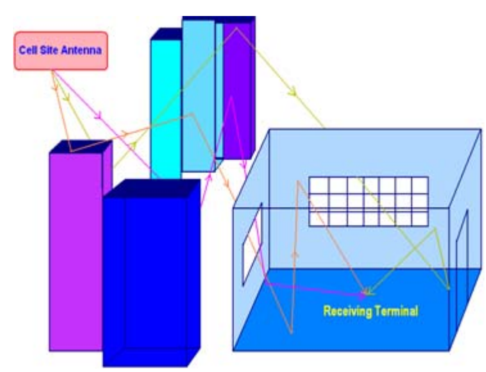

Fig. 2 : Signal Scattering in Wireless Environment

Thus directional antennas may be used. An omnidirectional antenna not only receives signal from all directions but also receives noise from all directions. A directional antenna receives noise only from a particular direction, resulting in better communication.

II. ANTENNA STRUCTURE

Slot is inclined at an angle Φ with respect to the microstrip feed line, just below the centre of the radiating patch (Figure 3).

This microstrip line is fed by a co-axial SMA connector in the second substrate. Patch dimensions are 12mm X 4.4mm. Dimensions of the feed line are 5mm X 1mm. Part of the feed line which appears beyond the centre of the radiating patch is stub line and this stub line is important for impedance matching. Here, stub line length is 2.5mm. Dimensions of the inclined slot are 1.5mm X 0.5mm.

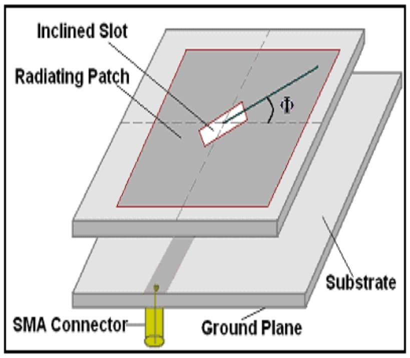

Fig. 3 : Inclined-Slot Loaded PCMA

After a large number of simulations, best results are obtained when inclination of the slot (Φ) is 45^0 with respect to the feed line. The dimensions of the ground plane of the fabricated antenna are 30mm X 25mm.

III. SIMULATED & MEASURED RESULTS

For antenna simulation, IE3D software is used and for measurement, Vector Network Analyzer (N5230A, Agilent Technologies).Antenna is fabricated on glass epoxy substrate with dielectric constant 4.36 and loss tangent of 0.01 and height of the dielectric substrate is 1.57mm. Optimum dimensions of the patch, slot, feed line and angle of inclination of the slot are determined after a large number of simulations, to achieve miniaturized size, broad bandwidth, best impedance matching and good gain of the antenna. Simulated radiation pattern of the antenna is shown in Figure 4, which is in broadside direction.

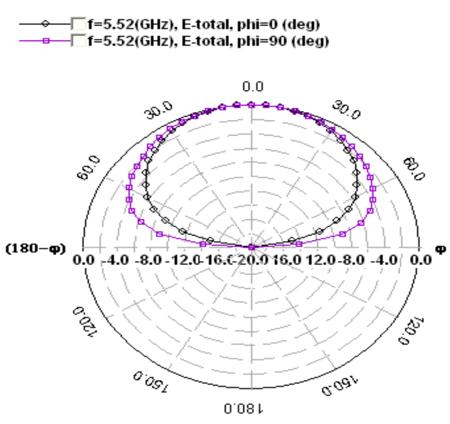

Fig. 4 : Radiation Pattern of the Inclined-Slot Loaded PCMA

Simulated and measured return losses are compared in Figure 5. Return loss (-10dB) bandwidth is 290MHz [5.40GHz – 5.69GHz].

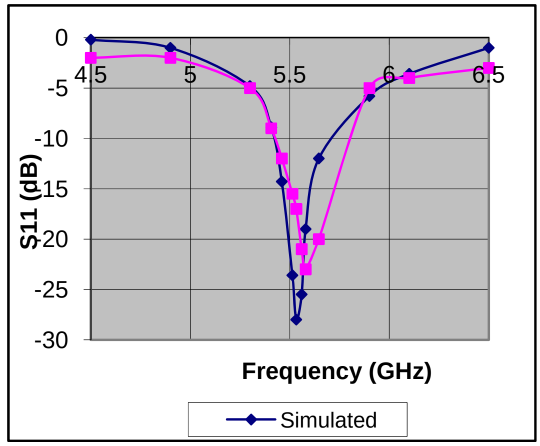

Fig. 5 : Simulated and Measured Return Losses

Simulated and measured return losses are compared in Figure 6. Over the bandwidth minimum and maximum gains of the antenna are 4.2 dBi and 5.1 dBi.

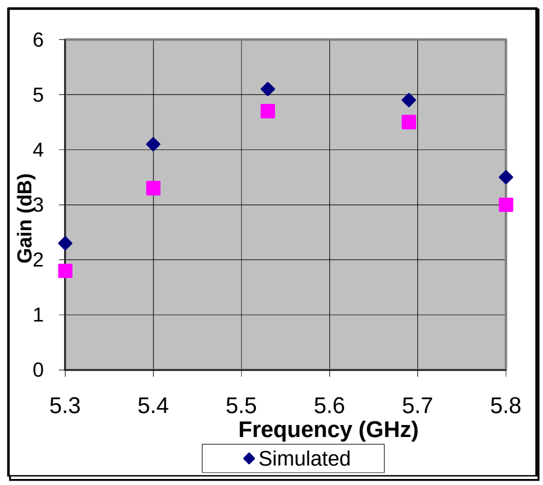

Fig. 6 : Simulated and Measured Gains of the Antenna

Gain of the antenna is measured at discrete frequencies by measuring transmission coefficient parameters (S_{21}) and using Friis transmission formula.Transmitted power (P_t) and Received power (P_r) can be related to the S_{21} by the expression $P_r/P_t = |S_{21}|^2$. According to Friis transmission formula,

$|S_{21}|^2 = (G_r^2\lambda^2)/(4\pi r)^2$, where gain of transmitted (G_t) and received antenna (G_r) are same. That is, gain of the receiving antenna is $G_r = (4\pi r/\lambda)\ |S_{21}|$, where 'r' and 'λ' are the separation between the antennas and the free-space wavelength respectively.

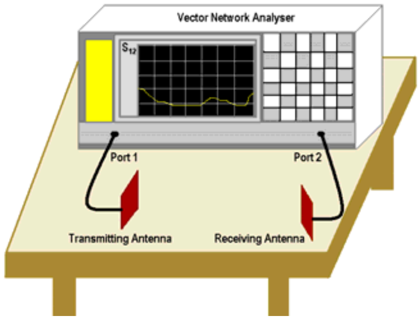

Fig. 7 : Experimental Setup for Gain Measurement

In simulation, the angle of inclination of the slot (Φ) is varied to observe the effect of inclination on the performance of the antenna (Figure 8).

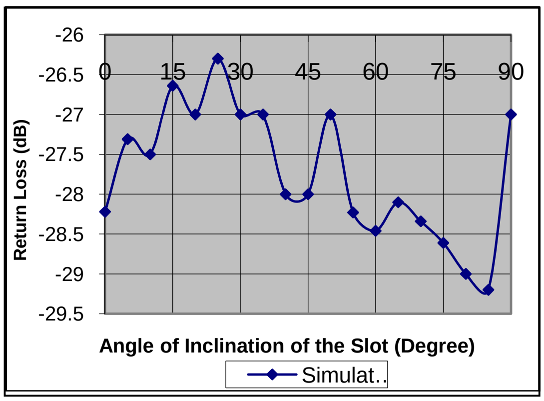

Fig. 8. Simulated Return Loss vs Inclination of the Slot

The variation of 2:1 VSWR bandwidth with angle of inclination is also investigated (Figure 9). Good impedance matching and highest bandwidth are achieved when the angle of inclination of the slot is 45 degree.

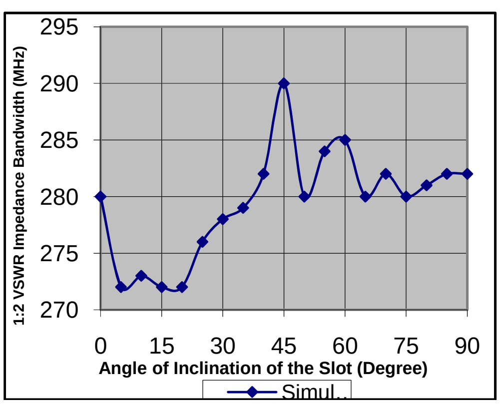

Fig. 9 : Simulated 2:1 VSWR vs Inclination of the Slot

Due to the variation of inclination of the slot, there are very small changes in resonance frequency, antenna efficiency and gain of the antenna, because these parameters principally depend on the peripheral dimensions of the antenna, which are kept constant.

IV. CONCLUSIONS

Performance of a miniaturized microstrip antenna for WLAN application is reported here. The simulation using IE3D shows that in order to achieve same characteristics, in the same frequency range, using PCMA, without loading by any slot, the required dimension of patch, on the same substrate, should be 12mm X 10mm and for proper impedance matching the dimension of the microstrip feed line should be 15mm X 4mm. Therefore using the proposed inclined-slot loaded PCMA the peripheral area of the patch is reduced by 65%. The feed line dimension is reduced by 90%. Due to miniaturization of the antenna, bandwidth also decreases. Here, after a large number of simulations, a miniaturized broadband antenna is designed at 5 GHz band.

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