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CPW-Fed Capacitive Coupled Slot Antenna

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ABSTRACT: Coplanar waveguide (CPW) fed slot antennas are attractive due to low dispersion and ease of integration with active and passive devices. In this paper, design of slot antenna fed by CPW through capacitive coupling with finite ground plane is presented. The propose antenna exhibit perfect impedance matching, unidirectional radiation patterns, and low cross polarization. Analysis of the effects of various slot dimensions on the parameters of the antenna design has been done. Proper simulated results are obtained by using a square slot of width $\boldsymbol{\lambda_g/2}$fed by CPW through capacitive coupling. The simulated results are obtained on Computer Simulation Technology (CST) Microwave Studio Software.

KEYWORDS: Coplanar waveguide,Microstrip antennas,Slot antennas, Conductor Backed, Capacitive Coupling.

I. INTRODUCTION

Slot antennas are currently under consideration for use in broadband communication systems due to their attractive features, such as wide frequency bandwidth, low profile, light weight, easy integration with monolithic microwave integrated circuit, low cost, and ease of fabrication [1]. These antennas have several advantages over common microstrip antennas as they provide good impedance matching, and bidirectional or unidirectional radiation pattern. Design of slot antenna using CPW feeding mechanism is done as it provides several advantages over microstrip line feed, such as low dispersion, low radiation leakage, ease of integration with active devices [2]-[3]. When the antenna is fed by microstrip line, misalignment can result because etching is required on both sides of the dielectric substrate. CPW feeding technique is used to excite the slot, since etching of the slot and the feeding line is one sided hence alignment error can be eliminated. In CPW the conductor formed a center strip separated by a narrow gap from two ground planes on either side.

The dimensions of the center strip, gap, thickness and the permittivity of the dielectric substrate determine the effective dielectric constant and the characteristic impedance of line [4]. Slot antenna results into wideband characteristic with CPW fed line having square slot [6] and CPW-fed hexagonal patch antennas [8] are demonstrated in the literature. In CPW-fed slot antenna by varying the dimensions of the slot and keeping it to the optimum value for wide bandwidth and proper impedance matching. In slot antenna geometries different tuning techniques has been carried out like circular slot [9], bow-tie slot [10], and wide rectangular slot [15].Various patch shapes such as hexagon, T, cross, forklike, and square are used to give wide bandwidth [6-12]. The dominant mode for the conductor backed CPW is quasi-TEM mode with zero cut off frequency. In [5], CPW fed rectangular slot antenna with ground plane is proposed.

Due to the rapid development in the field of satellite and wireless communication there has been a great demand for low cost minimal weight, compact low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies.An microstrip antenna[1] in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side The microstrip antenna, because of its small size, lightweight, low profile, and low manufacturing cost, is finding increasing applications in the commercial sector of the industry. In

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this paper, CPW feeding technique using capacitivecoupling with finite ground plane is presented. CPW fed dual band antenna generates two frequency bands one is 827 MHz-833 MHz and the other is 895 MHz-902 MHz.GSM can operate in the same network with different frequency bands. Now a days as dual band antennas or multiple band antennas are in great demand for multiple frequency applications. Proposed antenna is simulated using CST Microwave Studio package by utilising transient solver technique. Simulated results are compared by varying the slot width from $\lambda_g/2$ to $\lambda_g/4$ in order to obtain the perfect impedance matching at frequency 900 MHz.The dimensions of the slot is varied to obtain the optimum value of the slot so that the antenna resonates at frequency 900 MHz.

II. PROPOSED ANTENNA DESIGN MODEL

Fig. 1. illustrates the geometry of the proposed CPW fed capacitive coupled slot antenna with finite ground plane. The proposed antenna is formed by etching a half wavelength slot $\lambda_g/2$ located symmetrically with respect to the center of the CPW fed line,

$$\lambda_g = \frac{c/f}{\sqrt{\varepsilon_{eff}}} \quad (1)$$

whereε_{eff} is the effective dielectric constant of CPW fed line and f is the resonant frequency. In the CPW, the effective dielectric constant is independent of geometry and is equal to the average of dielectric constants of air and of the substrate.

$$\varepsilon_{eff} = \frac{\varepsilon_{air} + \varepsilon_r}{2} \quad (2)$$

CPW fed capacitive coupled slot antenna is simulated using FR-4 loss free substrate with ε_r= 4.3, height of the substrate h= 1.59 mm and loss tangent 0.01 with finite ground plane of size l × w 280 mm × 300 mm. Length of the slot is equal to half wavelength 102 mm using equation (1) and the width of the slot is$\lambda_g/2$. CPW feeding technique on thin substrate.

$$0.5 \leq W/h \leq 2.0 \quad (3)$$

$$\frac{S}{S+2W} \leq 0.4 \quad (4)$$

where S is the strip width and W is the gap width of a CPW fed line. Size of the strip width S and gap width W using equation (3) and (4) is 2 mm and 0.5 mm. Analysis of the antenna design parameters, reflection co-efficient, directivity, E-field pattern, H-field pattern are done by varying the width of the slot form $\lambda_g/2$ to $\lambda_g/4$. CPW is not very sensitive to substrate thickness and allows a wide range of impedance value from 20 Ω to 250 Ω. The characteristic impedance of CPW fed line is nearly about 50 Ω.

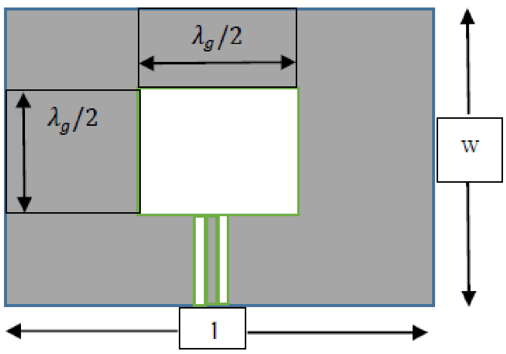

Fig. 1. Geometry of the proposed antenna fed by CPW. (Dimensions are in mm.)

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TABLE I. Design parameters of the antenna

Parameters	Description	Optimal Value
L	Length of the antenna	280 mm
W	Width of the antenna	300 mm
l	Length of the slot	102mm
w	Width of the slot	102 mm

Hence to overcome all drawbacks of cross-talk, dispersion, less gain and undesired radiation pattern is done by proposed design antenna model for desire frequency range using slot on the ground plane with **Conductor Backed CPW** feeding technique. The gap in the coplanar waveguide is usually very small and supports electric fields primarily concentrated in the dielectric. With little fringing field in the air space, the coplanar waveguide exhibits low dispersion. In order to concentrate the fields in the substrate area and to minimize radiation, the dielectric substrate thickness is usually set equal to about twice the gap width. In CPW a ground plane exists between any two adjacent lines, hence cross talk effects between adjacent lines are very week.

III. CONDUCTOR BACKED CPWANTENNA

Using conductor backed CPW it has additional ground plane at the bottom surface of the substrate. It provides mechanical support to the substrate and also acts as a heat sink for active and passive circuit devices. In CPW the conductors formed a center strip separated by a narrow gap from two ground planes on either side. The dimensions of thecenter strip, the gap, the thickness and permittivity of the dielectric substrate determined the effective dielectric constant, characteristic impedance and the attenuation of the line as shown in Fig. 2. In CPW, the substrate thickness plays a less important role due to the fact that the fields are concentrated in the slots. The dominant mode for the conductor backed CPW is Quasi-TEM mode with zero cut-off frequency.

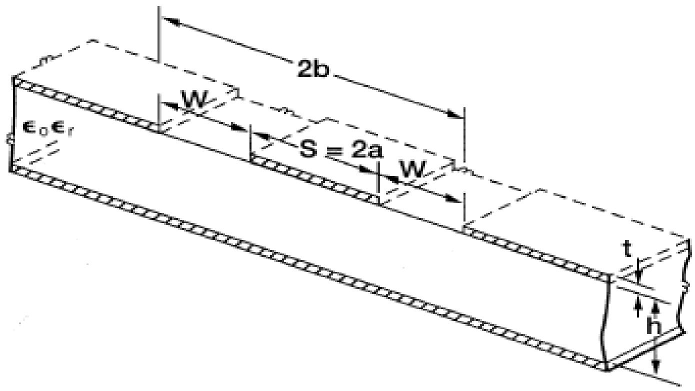

Fig. 2. Schematic of conductor Backed Co-planar Waveguide

CPW has ODD mode also called as Co-planar mode where the fields in the two slots are 180 out of phase and an EVEN mode known as coupled slotline mode where the fieldsare in-phase. Since the number of the electric and magnetic field lines in the air is higher than the number of the same lines in the microstrip case, the effective dielectric constant ε_{eff} of CPW is typically 15% lower than the ε_{eff} for microstrip, so the maximum reachable characteristic impedance values are higher than the microstrip values. The effect of finite dielectric substrate is almost ignorable if h exceeds 2b = W+2s.In CBCPW the leaky mode radiates power into space at an angle to the transmission line. The leaky higher-order mode is cut-off when itsnormalized leaky attenuation constant is greater than unity.

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IV. SIMULATION RESULTS

CST is used to simulate the proposed CPW fed slot antenna through capacitive coupling with finite ground plane. Fig.3shows the return loss of the proposed wide slot antenna, of width $\lambda_g/2$ perfectly resonates at frequency 900 MHz with dual band characteristics. By varying the slot width to $\lambda_g/4$ results into a shift in resonant frequency, from 900 MHz to 856 MHz.Return loss is S_{11}= -15 dB at 900 MHz frequency for the wide slot antenna, width of $\lambda_g/2$.

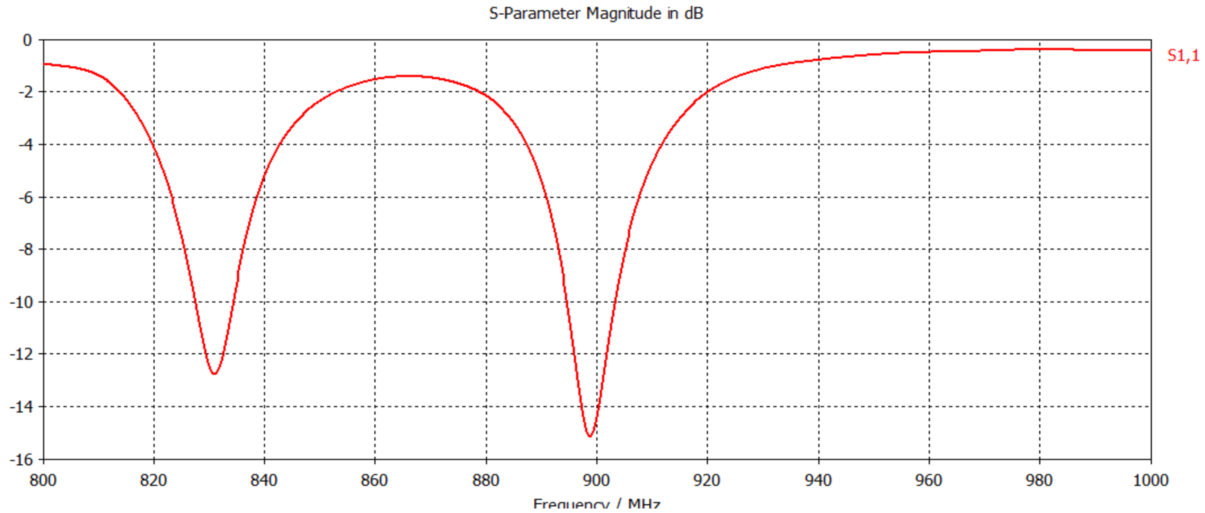

Fig. 3. Simulated results of the reflection co-efficient of wide slot antenna of width$\lambda_g/2$.

Fig. 4VSWR nearly equal to 1.3 shows that good impedance matching is observed for the wide slot antenna of width $\lambda_g/2$ at 900 MHz frequency

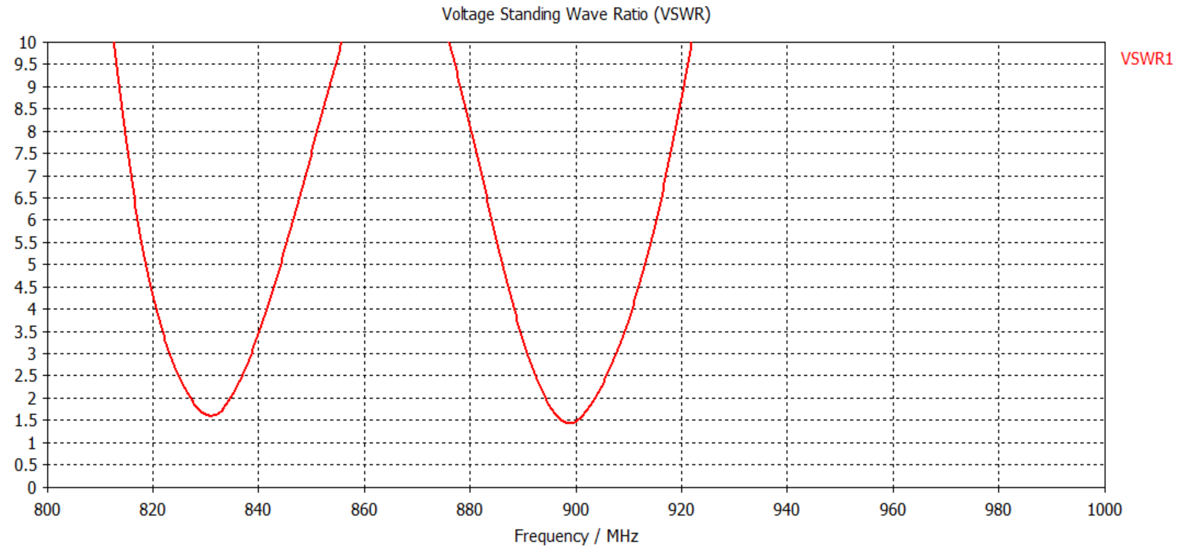

Fig. 4. VSWR of the proposed slot antenna fed by CPW

Fig. 5. shows that the main lobe magnitude is 11.0 Voltage (dBV/m), at frequency 900 MHz for E-plane when wide slot antenna width of $\lambda_g/2$ is designed using FR-4 substrate having ε_r= 4.3.

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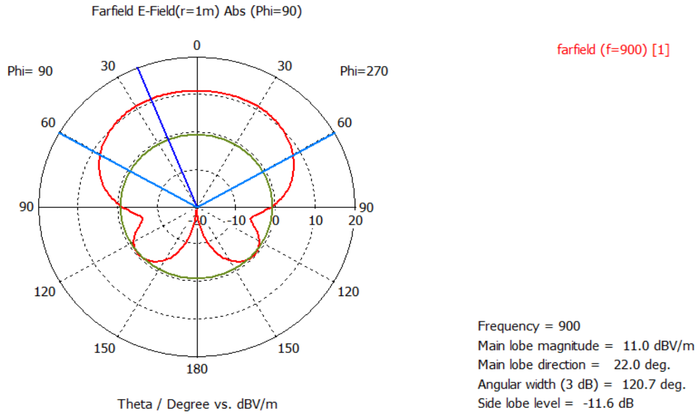

Fig. 5. Simulated radiation pattern of proposed antenna of E-plane.

Current density of the CPW fed capacitive coupled wide slot antenna with finite ground plane at 900 MHz as shown in Fig. 6.

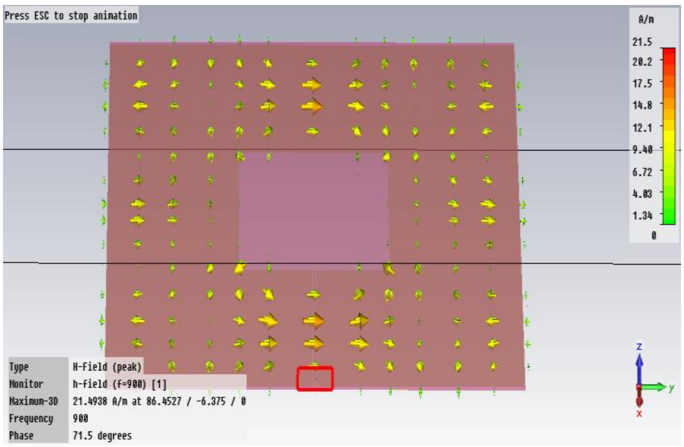

Fig. 6. Current distribution of CPW fed antenna at frequency 900 MHz.

V. CONCLUSION AND FUTURE WORK

CPW fed capacitive coupled slot antenna with finite ground plane is proposed. Good impedance matching is accomplished with capacitive coupled slot antenna at frequency 900 MHz with dual band characteristics. Proposed antenna exhibit low dispersion by using CPW feeding mechanism, unidirectional radiation patterns and low cross polarization. Simulated results illustrate that proposed antenna has better –10 dB return loss at resonant frequency 900 MHz for wide slot, width of dimension $\lambda_g/2$. Based on these characteristics wide slot capacitive coupled antennas fed by CPW with finite ground plane is suitable in aircraft navigation systems and for communication applications.

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BIOGRAPHY

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