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Design of Parallel L-Plate Feeding Differentially Driven Patch Antenna for GSM & PCS Application

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Abstract— In this paper a newly developed patch antenna, designated as the parallel L—plate patch antenna by feeding differentially driven is presented. The parallel-plate will not introduce inductance to the input impedance of a patch antenna; As a result of this height of the patch can be largely increased. Measurements show that the 3-dB-gain bandwidth can be obtained to 34.8% (0.86–1.93 GHz), return loss is -15.7dB, VSWR is 2 and impedance is 41 ohm at resonant frequency of 1.72GHz. The radiation pattern is stable and this antenna is designed for GPS application.

Keywords— 3-dB-gain bandwidth, differentially driven antenna, bandwidth, parallel L-plate feed line, CADFEKO.

I. INTRODUCTION

Now a days, the use of differential circuits are becoming more common in microwave circuit design, because it offers good performances such as absolute low noise, harmonic suppression, linearity becomes high, and dynamic range increases many times. Thus they are suitable for radio frequency integrated circuits (RFICs) and microwave monolithic integrated circuits (MMICs) [1] [2]. Although, most antennas are designed for single-ended circuits but Baluns are used to convert differential signals to single-ended signals, when they are designed with differential circuits. Thus, differentially driven Antennas are in great demand in differential microwave designs to get rid from bulky off-chip as well as lossy on-chip baluns to improve the receiver noise performance or transmitter power efficiency However, the differentially driven scheme used for cancellation mechanism reduces the cross-polarization radiation and As a result enhances the polarization purity of the antenna [1] [3] [6]. The most demanded features for patch antennas are Stable radiation and Wide gain bandwidths. In order to achieve 3-dB bandwidth increased the height of the patch above the ground plane increase significantly. However, the inductance plays an important role in the feeding structure; the height of the patch is kept such that it can limit within a few per cent of a wavelength. For coaxial probe feeding, the height of the probe has to be increased with the height of the patch, which introduces extra inductance to the input impedance and deteriorates the input matching of the antenna. This effect limits the bandwidth of patch antennas [8].

A numerical study of newly developed patch antenna, designated as the parallel plate transmission line feeding differentially driven patch antenna has been presented. The parallel plate transmission line will not introduce inductance to the input impedance of the patch antenna, thus the height of the patch can be largely increased.

II. ANTENNA DESIGN

A. Electrical Parameters of Differentially Driven Antenna:

For symmetric differentially Driven patch antenna, the differential input impedance Z_d is given by [5]

$$Z_d = Z_{11}-Z_{12}-Z_{21}-Z_{22} \quad (1)$$

Where Z11, Z12, Z21 and Z_{22} are Z-parameters of two input ports when the differentially driven antenna is regarded as a two port single-ended network. The frequency at which the reactance of the input impedance Z_d is equal to zero is known as resonant frequency [5]. From (1), we achieve the following relation as:

$$S_{d11}=1(S_{11}-S_{12}-S_{21}-S_{22})/2 \quad (2)$$

Where S_{d11} is the reflection coefficient of differentially driven antenna.S_{11}, S12, S21 and S_{22} are S-parameters of two input ports when the differentially driven antenna is regarded as a two port single-ended network. In this paper, the 3-dB gain bandwidth of the differentially driven patch antenna is defined as a range of frequencies over which the differential reflection coefficient is less than 10 dB (S_{d11}<-10 dB).

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B. Antenna Design:

The basic structure of the proposed antennas consists of a ground plane, a parallel L-plate transmission line formed by two parallel L-plates, and a radiation patch. For conventional single ended probe feeding, the series inductance introduced by the probe is from the self-inductance of the probe. The longer the probe is, the larger the inductance will be introduced. This deteriorates the input matching of the antenna. On the other hand, the connection between the parallel plate and other parts of the antenna will also introduce a reactive component to the input impedance. However, according to the transmission line theory, series distributed inductance and shunt distributed capacitance make the parallel plate becomes a transmission line. From the microwave network theory, we know that the transmission line itself does not introduce a reactive component, but only changes the phase of signals. Thus, no matter how long it is, the parallel plate will not introduce extra inductance to the input impedance. By this way, the height of the patch fed by the parallel plate can be largely increased. Two lower edges of the parallel-plate transmission line are connected to two short feeding probes of two 50ohm SMA launchers. The characteristic impedance of the differential feeding line, thus, is 100ohm. The short feeding probes are inevitable, but will only introduce small inductance to the input impedance of the antenna. The two SMA ports below the ground, together, are designated as the “differential input port” of the differentially driven patch antenna in [1].

For the antennas proposed in this paper, the ground plane is made with the thickness of 2 mm. The radiation patch and parallel-plate transmission line are made with the thickness of 0.3 mm. The radii of the two probes are 0.025 mm.

Then, the upper edges of the parallel plates are bent to be horizontal, which is called L-plate here. L-plate compensates the inductance introduced by the two short coaxial feeding probes; antenna is shown in Fig. 4, where the optimized geometrical parameters of the antenna are also given.

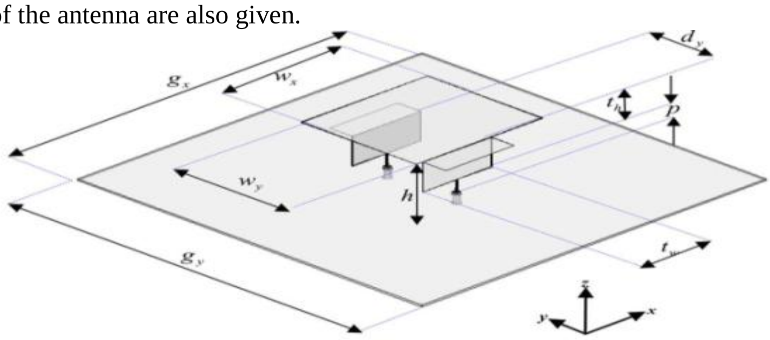

Fig.1Geometry of Parallel L-Plate direct-feeding differentially driven patch antenna

The radiation patch is placed over a ground at the height of 43mm from the ground plane. For this antenna, the horizontal parts of the L-plate with the patch act capacitive within a certain frequency range. Together with the inductance of the two short probes, the overall structure acts as a series differential resonant element, and a new resonance close to the other three resonances is introduced. Thus, compared to the first antenna, there is one more resonance.

The 3-Db-gain bandwidth of the antenna is34.8 % (0.86–1.93 GHz) centred at 1.72 GHz.

The geometry of the first antenna is shown in Fig. 1, where optimized geometrical parameters of the antenna are also given as shown in table 1.

Table 1

Parameter	g_x=g_y	t_w	t_h	p	h	d_y	w_y	w_x	p_g
Value(mm)	300	60	34	3	43	43	100	110	6

The simulation process has been done through FEKO electromagnetic software which is based on method of movement (MOM). The optimization is done through FEKO simulation software. It was used for optimizing electromagnetic problems. The optimized antennas were determined to have desired resonant frequencies, high gain, and low weight return losses.

The radiation patch is placed over a ground at the height of 38mm. The 3-dB-gain bandwidth is 65% (0.86–1.93 GHz). It can be observed that the proposed antenna has a Return loss of -20 db, VSWR is less than 2 and impedance is 51ohmat the resonant frequency of 1.58GHz. It is noted that the resonances occurs at 1.58GHz.

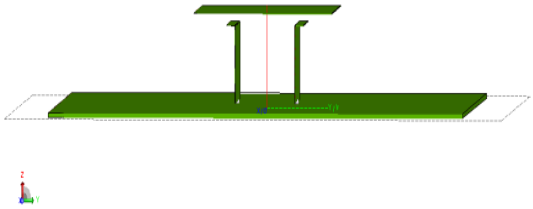

Fig.2 Parallel L-plate Feeding Differentially driven patch antenna in CADFEKO

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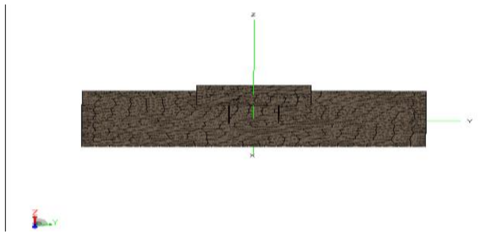

Fig.3 Parallel L-plate Feeding Differentially driven patch antenna in POSTFEKO

III. RESULTS AND ANALYSIS

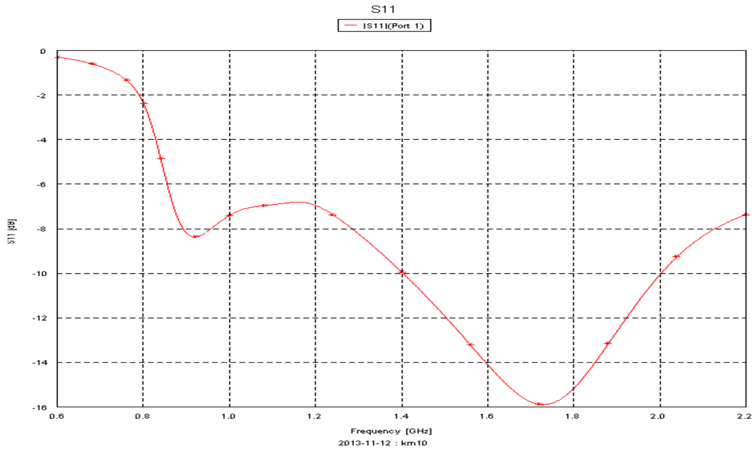

Fig.4 Return loss Vs frequency

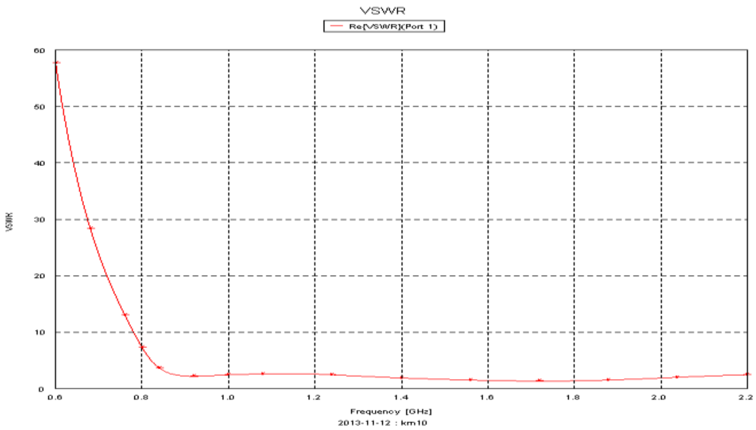

Fig.5 VSLR Vs frequency

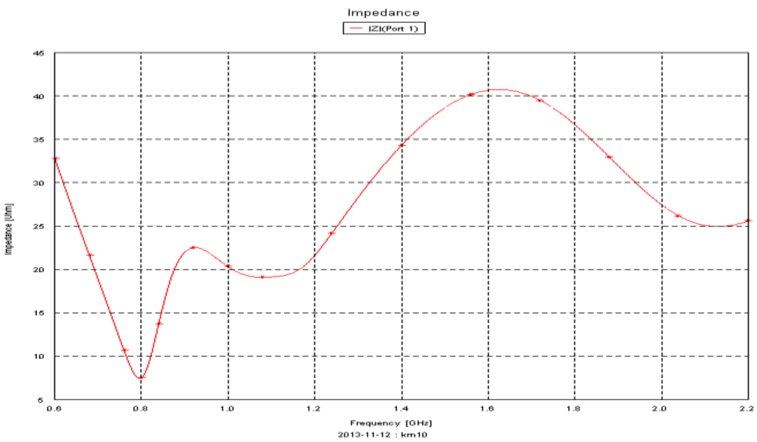

Fig.6 Impedance Vs frequency

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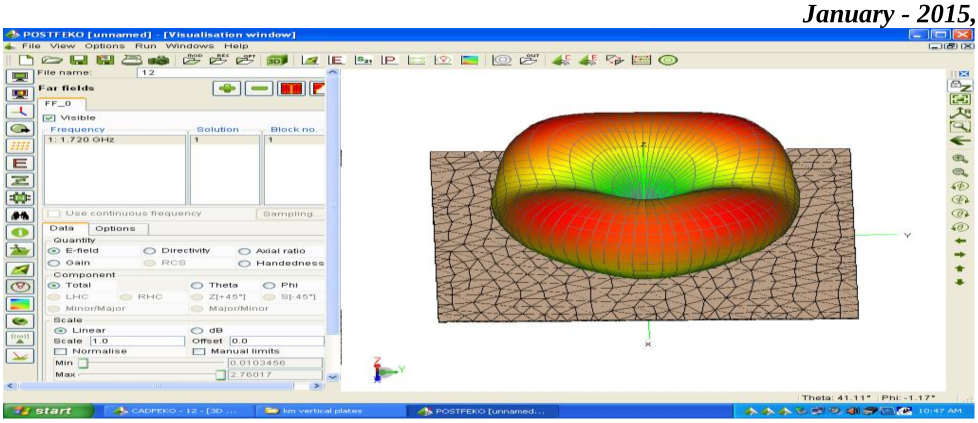

Fig.7 3-D view of radiation pattern

IV. CONCLUSIONS

A newly developed single-patch antenna, called parallel L-plate feeding differentially driven patch antenna, has been designed and implemented successfully. The measured results demonstrated that it has a wide 3-dB-gain bandwidth of 34.8% (0.86–1.93 GHz), return loss is -15.7dB, VSWR is 2 and impedance is 41 ohm at resonant frequency of 1.72GHz. The radiation pattern is stable within the 3-dB-gain bandwidth. Due to the symmetry of the structure and excitation, the radiation pattern is symmetric about both E-plane and H-plane. Due to its wide bandwidth, a possible application of the proposed antenna is that it can be used as a base-station antenna, simultaneously providing different wireless access services, e.g. GSM1800 and PCS applications.

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