A Printed Collinear Dipole Array in S Band for High Gain Applications

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Abstract:
In the present work, we have described the design and development of collinear printed dipole array (CPDA) for ground based S band communication system. Multiple printed dipole radiators are placed in the form of collinear array to produce high gain. Two CPDA schemes have been studied with and without reflector. The gain of CPDA increases when a planar reflector is placed adjacent to it; however, in this case the radiation pattern becomes directional.

Key Words: Collinear printed dipole array, High gain omni antenna

I. INTRODUCTION

The class of dipole antennas are most common and widely used for a large number of wireless applications among all types of antennas. Generally, dipoles are applicable for the systems with low gain and omni directional radiation requirement. However, the utility of dipole can be extended to high gain applications also when multiple dipoles are arranged in specific collinear array configuration. Appropriate placement of a planar reflector near the collinear array further enhances the gain of the antenna. In the present work, we have explored the feasibility of various collinear dipole antenna schemes to meet the requirement of moderate gain antenna for a specific ground based data communication system to operate in S Band.

The conventional wire based dipole antenna has been transformed to its printed form and they are being used extensively. The printed antenna technology offers flexibility of the design to form various printed geometrical shapes on the substrate. The technique has been adopted for the realization of printed dipole antenna (PDA) and collinear printed dipole array (CPDA) configurations.

Primarily, the architecture of printed dipole antenna has been studied followed by investigating the effects on the PDA due to a planar reflector near to it. The procedure is repeated for a dual dipole collinear antenna also. These antenna schemes have been designed and simulated using IE3D electromagnetic simulation code and the performance is verified experimentally. Further, a quad CPDA has been designed and developed. The simulation and experimental results of these antennas are discussed.

II. PRINTED DIPOLE ANTENNA (PDA)

1. Basic PDA Architecture

A basic printed dipole antenna (PDA) configuration as shown in Fig 1 (a) has been designed with two printed radiating arms of length "L_d" & width "W_d". The dipole arms are printed on either sides of the substrate with dielectric constant = 2.5 & thickness = 1.6 mm and is fed through twin printed strip line which works as a "balun" (balance to unbalance unit). The length of the balun "L_b" is equal to the length of the dipole arm which is approximately $\lambda/4$. The balun in the stripline form is printed in a manner similar to the dipole arms as indicated in Fig 1. A 50Ω coaxial connector is used for exciting the antenna with guided wave as shown in the Fig.1(b).

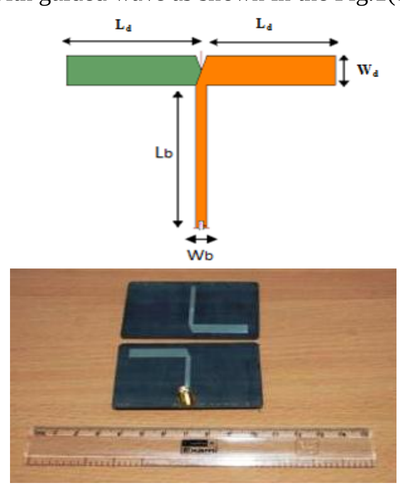

Fig 1: Printed Dipole Antenna (a) Schematic (b) Hardware

Fig 2 gives the VSWR results of the PDA. The operational bandwidth of the PDA is obtained by measuring its VSWR (2:1) and found to be 220 MHz against the simulated 200 MHz in S band. The simulation and experimental patterns (E & H Planes) are given in Fig. 3 (a) & (b) respectively. The experimental patterns have been measured in the anechoic chamber and found to be identical to their simulated counterparts, which confirms the accuracy in the process of design and development of the PDA undertaken.

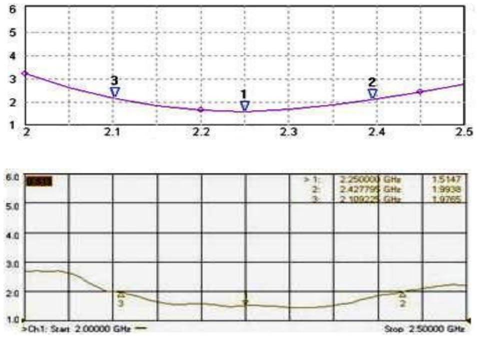

Fig 2: PDA VSWR Plots (a) Simulation (b) Experimental

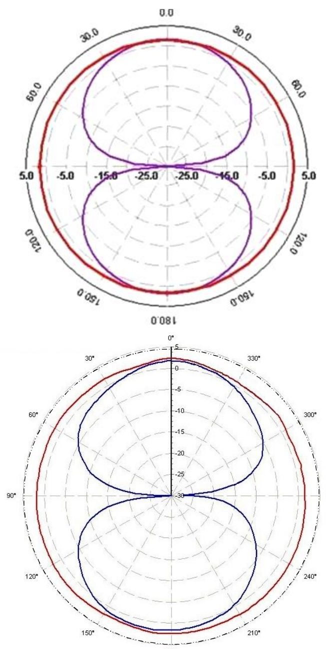

Fig 3: PDA Patterns: E Plane & H Plane (a) Simulation (b) Experimental

2. PDA with Reflector

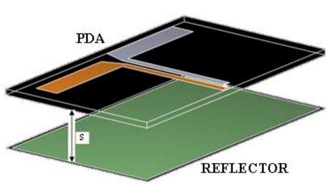

Fig 4: PDA with Reflector

A flat reflector which is of the same size of the PDA is placed in parallel to it at a close separation ósô as shown in the schematic at Fig 4. It is observed that there is considerable shift in the resonating frequency (approximately 150 MHz downwards). The reflector also contributes towards the antenna pattern which becomes directional with a gain of 7.0 dBi. The performance of PDA with reflector has been confirmed through experimental measurements. Simulation and measured results of the antenna for VSWR and radiation pattern are given in Fig 5 and Fig 6 respectively. The operational bandwidth of the antenna has increased from the previous design of without reflector. The radiation pattern is directional with a gain of 7.4 dBi. The experimental pattern finds close agreement with the simulated pattern.

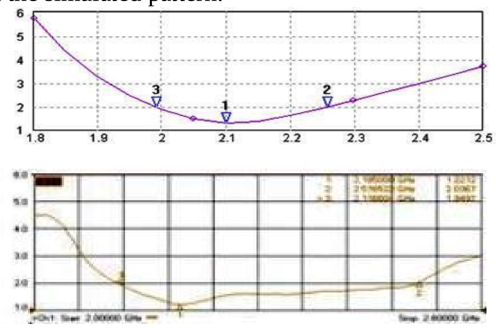

Fig 5: VSWR Plot of PDA with Reflector(a) Simulation (b) Experiment

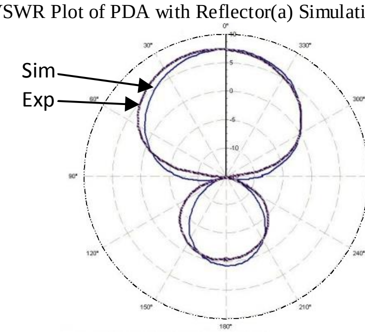

Fig 6: Simulation & Experiment Patterns of PDA with Reflector

III. COLLINEAR PRINTED DIPOLE ARRAY (CPDA)

A collinear printed dipole array antenna scheme has been presented in this section. The printed collinear dipole array has been incorporated for higher antenna gain. In this scheme the individual dipoles are separated by approximately λ and fed using appropriate transmission line. The power is distributed equally to both the radiating dipoles such that their individual patterns are added to produce enhanced gain with narrower beam-width.

1. Two Element CPDA

The schematic of the two element CPDA is shown in Fig 7. The parallel feed network is used for feeding equal power to both the dipoles. The simulation and experimental VSWR results are shown in Fig 8. The impedance bandwidth is measured and found to be 450MHz. The radiation patterns of two element CPDA are as shown in Fig 9. It gives a narrower beam with omni pattern in broad side of the antenna with gain of 5 dBi.

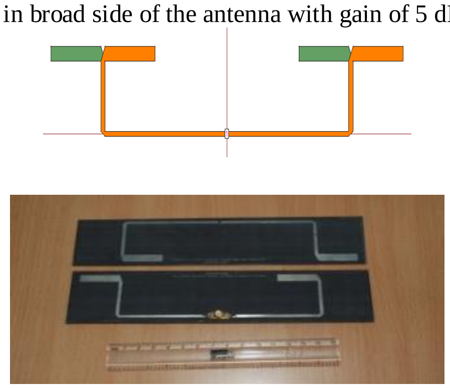

Fig 7: Two elements PDA schematic & hardware

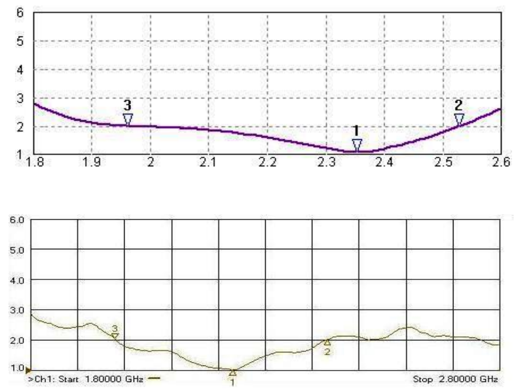

Fig 8: Two elements CPDA VSWR Plots (a) Sim & (b) Exp

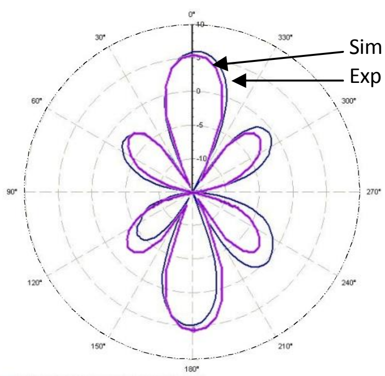

Fig 9: Simulation & Experimental Patterns of Two elements CPDA

2. Two Element CPDA with Reflector

As in the case of PDA, the incorporation of the ground plane improves the directivity of the antenna. A similar study has been carried out by placing a metallic plate in close proximity of the dual CPDA. The fabricated hardware with reflector is shown in Fig 10. The comparisons of simulation and measured VSWR and patterns are shown in Fig. 11 & 12 respectively. The gain achieved in this design scheme is 10 dBi.

Fig 10: Hardware of PDA & Two elements CPDA with reflector

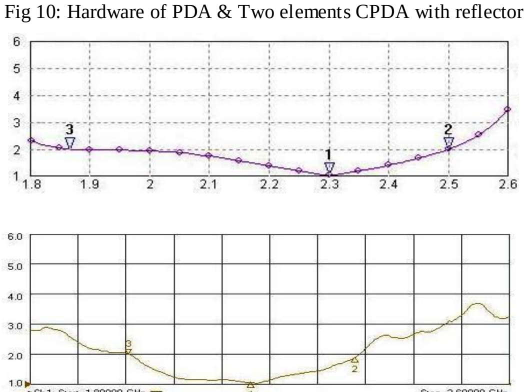

Fig 11: Two elements CPDA VSWR Plots (a) Sim (b) Exp

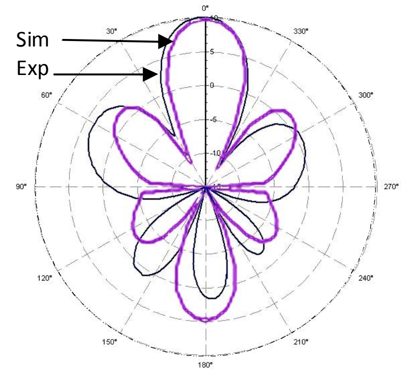

Fig 12: Two elements CPDA Radiation Patterns (a) Sim (b) Exp

3. Four Element CPDA

The four element CPDA has been designed to obtain high gain with omni pattern. The geometry and hardware of the array are shown in Fig 13. Appropriate feed network has been incorporated for impedance matching. The gain achieved in this design scheme is 10 dBi with omni coverage and a narrow beam-width of 8 degrees. The comparisons of simulation and measured VSWR and patterns are shown in Fig. 13 & 14 respectively.

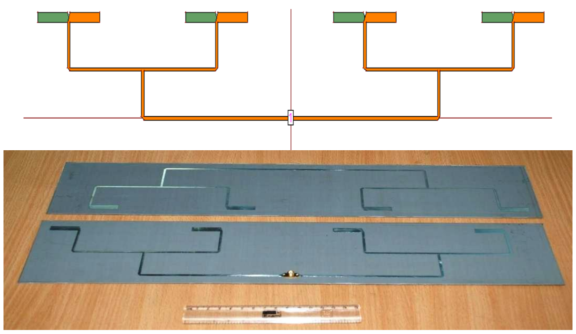

Fig 13: Four elements CPDA (a) Schematic & (b) Hardware

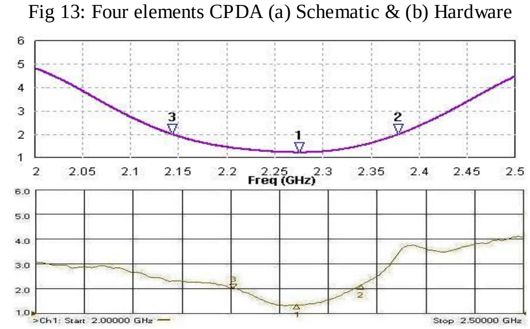

Fig 14: Four-element CPDA VSWR Plots (a) Sim (b) Exp

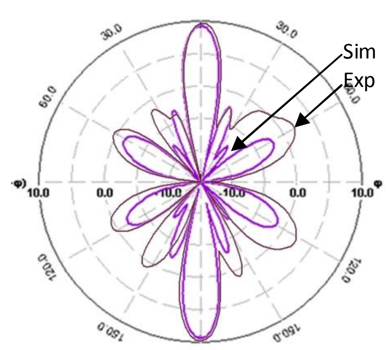

Fig 15: Simulation & measured patterns of Four element CPDA

IV. Conclusion

An analytical study of Printed Dipole Antenna as a single radiating device and in the form of Collinear Printed Dipole Arrays have been carried out. The effect of planar reflectors on PDA & CPDA configuration has been investigated and their results were reported. The four element CPDA with 10 dBi and omni pattern in the broad side has been considered for the intended application.

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