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Design of MPA for RF Front-end Transceivers Operating at 3.5GHz

Mr. Shon Nemane[1], Prof.V. N. Bhonge[2]

PG Student, Dept of E and TC, Shri Sant Gajanan Maharaj COE, Shegaon, India[1]

Associate Professor, Dept of E and TC, Shri Sant Gajanan Maharaj COE, Shegaon, India[2]

Abstract: Microstrip patch antenna (MPA) was designed in Advance Design System (ADS) Momentum Microwave. The resonant frequency of which is 3.5 GHz. FR4 substrate (ϵ_r=4.4) is used for this microstrip patch antenna design. The transmission line perfectly was matched perfectly to the impedance of the rectangular patch. The design is simulated in ADS simulator. S11 was -2.71dB, S11mag=-39.86dB where as S21was 6dB. The antenna was simulated and results are obtained for various parameters.

Keywords: Microstrip line Patch antenna, FR4 and Return Loss.

I. INTRODUCTION

Microstrip patch antennas are useful and can be printed directly onto a circuit board. Microstrip antennas are low cost, have a low profile and are easily fabricated [2]. It is a very dominant in communications and radar applications since it provides a wide variety of designs, either planar or conformal. In this paper a patch antenna is designed in ADS momentum microwave simulator.

II. MICROSTRIP PATCH ANTENNA

A microstrip patch antenna is a low-profile antenna and has ease of fabrication, lightweight, inexpensive, compatibility with integrated circuit technology, and conformability with a shaped surface. So they are planar antennas.[1]-[4]

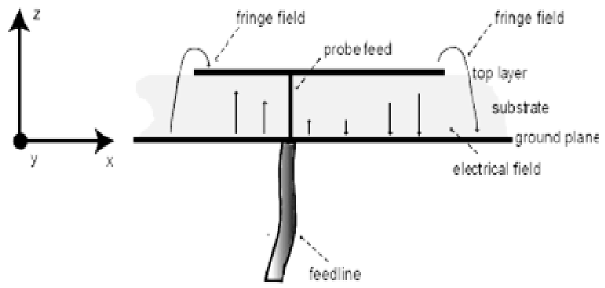

Fig1-Patch Antenna

The fig 1 shows a patch antenna in its structured form. The electric field distribution of a rectangular patch excited in its fundamental mode TM10 or TM01.

The electric field is zero at the center of the patch, maximum (positive) at one side, and minimum (negative) on the opposite side. It should be mentioned that the minimum and maximum continuously change side according to the instantaneous phase of the applied signal [6]. The electric field does not stop abruptly at the patch's periphery as in a cavity; Rather, the fields extend the outer periphery to some degree. These field extensions are known as fringing fields and cause the patch to radiate. Some popular analytic modeling techniques for patch antennas are based on this leaky cavity concept. Therefore, the fundamental mode of a rectangular patch is often denoted using cavity theory as the TM10 mode or TM01 mode [3].

III. ADS MOMENTUM MICROWAVE

Momentum is a part of Advance Design System and it provides the simulation tools required to evaluate and design products of modern communication systems. Momentum is an electromagnetic solver in the form of a simulator that computes the S-parameters for general planar circuits which includes microstrip, slotline, stripline, coplanar waveguides and many other topologies. Multilayer communication circuits and printed circuit boards can also be simulated in ADS Momentum with accurate results. Momentum is a complete tool for prediction of the performance of high frequency circuit boards, antennas and integrated circuits [3]-[5].

The ADS Momentum optimization tool extends Momentum capability to a real design automation tool. The Momentum Optimization process varies geometry parameters automatically to help in achieving the optimal structure that for the circuit or device performance goals. Momentum optimizations can be done by using layout components (parameterized) from the schematic page. One of the great advantages that Momentum possesses is the 3-dimensional interface that it provides for the user during simulations and results. Momentum is a 2.5D solver that can do both 2D and 3D computations. For example while computing the antenna parameters, Momentum provides both 2D and 3D graphs of the directivity and the far-field radiation patterns of the antenna[10].

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IV. DESIGN AND RESULTS

A. Design of a Rectangular Patch Antenna for WIMAX

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

= 26.08202mm

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}$$

= 3.990198

$$\Delta L = 0.412h\frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)}$$

=0.73400mm

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

= 19.9868 mm

A rectangular patch with TM10 mode is designed in ADS Momentum Microwave. The length of the patch is 19.9868mm, the width ofthe patch is 26.08202mm and the height of the patch is 1.6mm. Permittivity of the substrate is 4.4 and the resonance frequency is 3.5 GHz. FR4 is used as a substrate with a substrate height of 1.6 mm[1].

B. Gain and Directivity

The patch's radiation at the fringing fields results in a certain far-field radiation pattern. This radiation pattern shows that the antenna radiates more power in a certain direction than another direction. The antenna is said to have certain directivity.[8]-[9] One of the main features of the ADS Momentum is that it can give us both the 2D and 3D graphs of the gain and directivity of the system. Fig. 5 shows the gain and directivity of the patch antenna simulated in ADS Momentum.

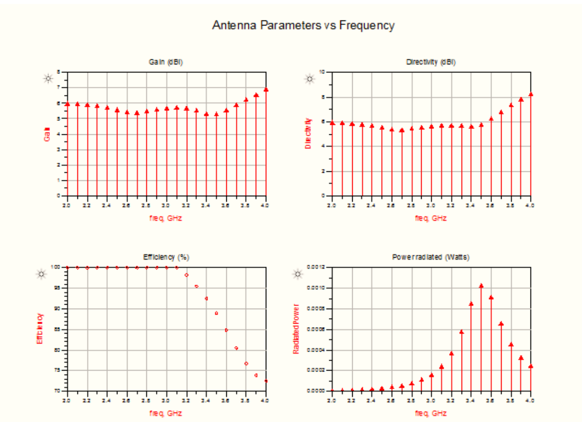

Fig-2 Antenna parameters Vs Frequency

The rectangular patch excited in its fundamental mode has a maximum directivity in the direction perpendicular to the patch (broadside). The directivity decreases when moving away from broadside towards lower elevations. The 3dB beamwidth (or angular width) is twice the angle with respect to the angle of the maximum directivity, where this directivity has rolled off 3dB with respect to the maximum directivity.

C. Bandwidth

The bandwidth of an antenna is defined as "the range of frequencies within which the performance of the antenna, with respect to some characteristics, conforms to a specified standard". The bandwidth can be considered to be the range of frequencies on either side of the center frequency where the antenna characteristics are close to those at the center frequency. Directivity and efficiency are often combined as gain bandwidth[7].

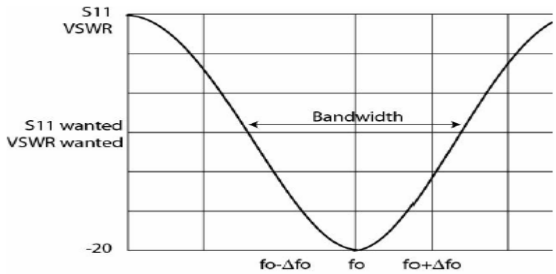

Fig3-S11 vs bandwidth

V. SIMULATION & ANALYSIS

Impedance Matching is achieved at 3.5 GHz using RL section as shown in fig4

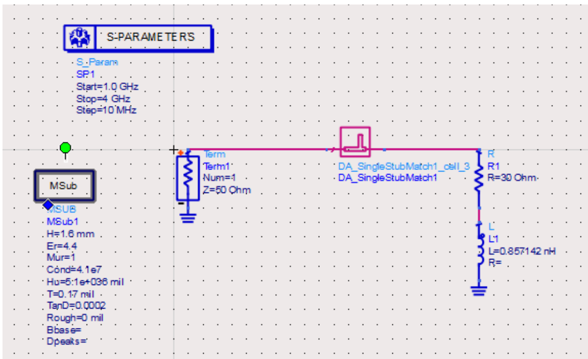

Fig4-Single stub matching using RL circuit

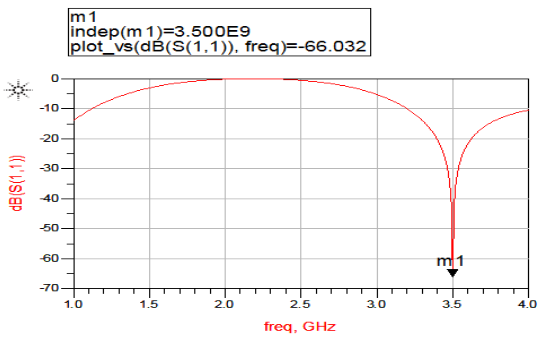

Fig5- Return loss at 3.5 GHz for RL circuit.

Circuit model in ADS for 3.5GHz with matching section is as shown below

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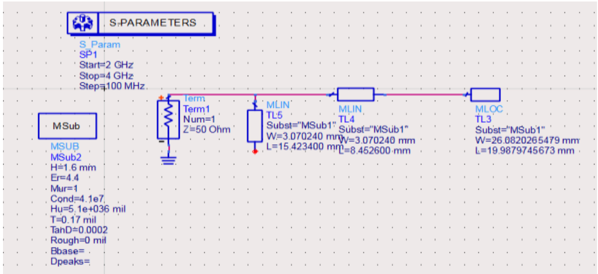

Fig6- Circuit model of MPA at 3.5 GHz in ADS

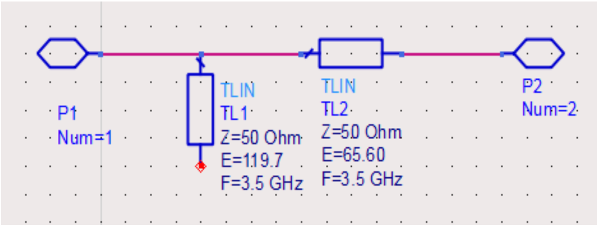

Fig7- Matching parameters of transmission line at 3.5 GHz

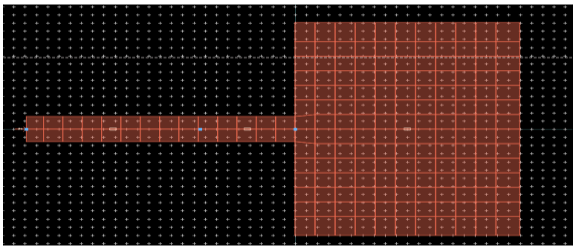
Fig8-Generated Layout for designed antenna at 3.5 GHz

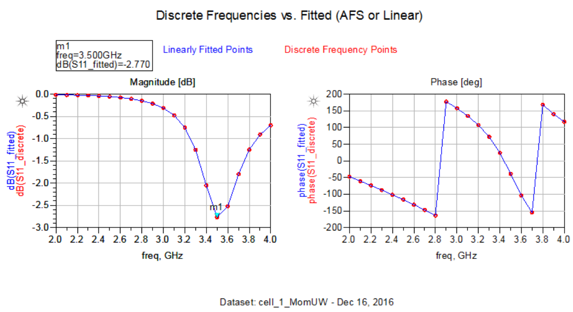

Fig9-Return loss Vs frequency

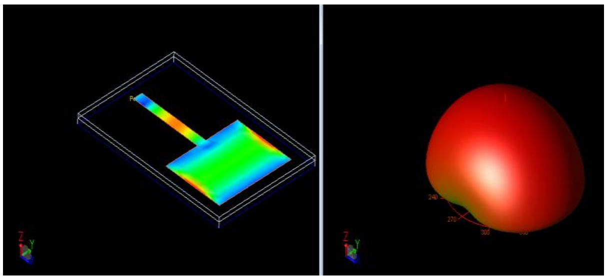
Fig10-Radiation pattern with Current distribution in MPA at 3.5 GHz.

Dataset: emFar - Dec 16, 2016

Frequency	E_max	Theta_max	Phi_max	Directivity_max	Gain_max	RadiatedPower	InputPower	Efficiency	CutType	CutAngle
3.500E9	0.497	17.000	180.000	5.948	5.438	0.001	0.001	0.889	Phi	90.000

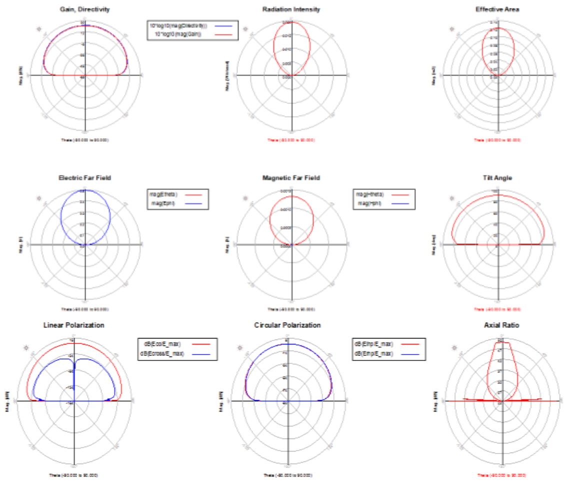

Fig11-Theta and Phi cuts for 30 and 90 degrees.

This patch was designed in ADS Momentum. After design, the patch was simulated in ADS Momentum to get the directivity, the gain curves along with the 3D visuals of the far field radiation and the 3D view of the designed antenna patch.

VI. CONCLUSION

A rectangular patch antenna is designed on FR4 substrate using ADS momentum. The layout is simulated in momentum microwave simulator. The designed antenna gives a resonant frequency 3.5GHz.

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