Design of Microstrip Rectangular 8x1 Patch Array Antenna for WiMAX Application

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Abstract.: In our daily lives, wireless communications are becoming increasingly significant. The antennas needed for these applications should be light weight, conveniently mountable, and have a broad bandwidth due to the rise in data rates and a tendency of tiny electronic devices for wireless digital applications. These requirements can be met by Microstrip Array Antennas . In this paper, the rectangular microstrip patch array antenna of frequency 2.5-3.5Ghz for WIMAX applications is designed in computer stimulation tool (CST). The antenna is fabricated using FR-4 Substrate material. The designed antenna's performance is analysed in terms of voltage VSWR, s-parameters, radiation pattern, gain, directivity.

1 Introduction

Advancement of technology for communication has significantly risen and shows no signs of slowing down, not the least of which is the wireless communication system. The popularity of wireless communication systems like Cellular Communication and WiMAX (Worldwide interoperability Mobile Access) as well as their service applications is growing alongside the development of advanced technology. These systems have a number of advantages over other types of technology, including the ability to offer users communication services at any time and from any location. Such wireless communication systems require communication equipment that can achieve preset standards in order to facilitate the transfer of data, voice, and multimedia with high speed access from base station to client. Antennas with high board bandwidth, low weight, high efficiency, and gain are required for these applications. It can be achieved using microstrip patch array antennas, which offer numerous advantages over a single microstrip antenna. The paper is structured as follows. Section 2 focuses about the physical description of an antenna. Parameter analysis is covered in section 3 whereas simulation in CST is covered in section 4. Results are discussed in section 5 and the conclusion is then presented.

2 Physical Description

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The single elements and arrays of microstrip antennas are used. Using an array in communication systems allows us to improve the antenna's performance in terms of gain, directivity, beam scanning, and other tasks that are challenging to do with a single element.

2.1 Single Element Microstrip Antenna Design

A microstrip antenna consists of a ground plane on one side of a dielectric substrate which has a radiating metal patch on the other side.

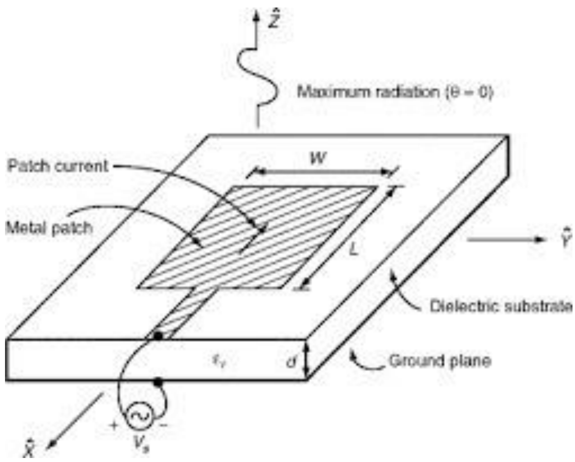

Fig. 1. Sketch of Single Element Microstrip Antenna

2.2 Microstrip Patch Array Antenna Design

The feed network is used for designing eight element array networks.

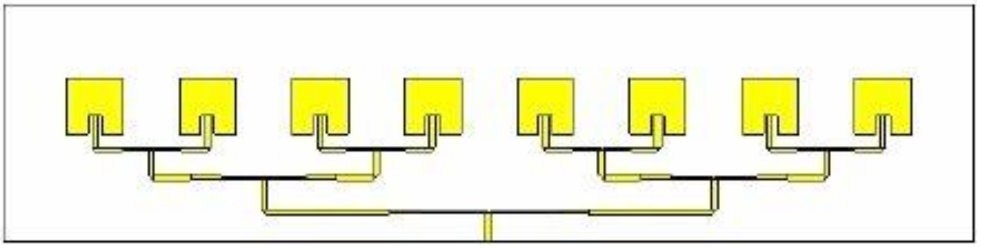

Fig. 2. Caption of the Figure 1. Below the figure.

Table. 1. Design Specifications for Microstrip Patch Antenna

Centre Frequency, f_0	2.6 GHz
Substrate	FR-4
Relative Permitivity	2
Loss Tangent	0
Substrate height	2.64
Metal thickness	3.74

3 Parameter Analysis

Calculation process of microstrip patch antenna . At first, a 2.6 GHz operational frequency that ranges from 2-4 GHz has been chosen. Width of the patch was computed from Equation-1, using the operating frequency (fr), dielectric constant (r), and Velocity of Light(Co).

$$W = \frac{c_0}{2f_r\sqrt{\frac{\varepsilon_r + 1}{2}}} \quad \textbf{(1)}$$

The Effective Dielectric Constant, εreff has also been calculated using Equation (2).

$$\varepsilon_{\mathrm{reff}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + 12\frac{h}{w}\right)^{-0.5} \quad \textbf{(2)}$$

‘h’ represents substrate’s height, and w represents the size of the patch.
Effective Length (Leff) can be calculated using Equation (3).

$$L_{\mathrm{eff}} = \frac{c_0}{2f_r\sqrt{\varepsilon_{\mathrm{reff}}}} \quad \textbf{(3)}$$

Computing the ΔL-length extension's Because of the effect of fringe, the microstrip patch antenna seems longer than its actual length.

$$\Delta L = 0.412\frac{\left(\frac{w}{h} + 0.264\right)(\varepsilon_{\mathrm{reff}} + 0.3)}{(\varepsilon_{\mathrm{reff}} - 0.258)\left(\frac{w}{h} + 0.813\right)} \quad \textbf{(4)}$$

As a result, the effective length is ΔL shorter than the actual length. Measurement of the patch's actual length. By deducting the effective length from the length ofΔ L's extension, we may determine the real length.

$$L = L_{\mathrm{eff}} - 2\Delta L \quad \textbf{(5)}$$

4 Simulation on CST

Firstly, we designed single element microstrip antenna. Further we designed 8X1 MICROSTRIP PATCH ARRAY ANTENNA. The following are images captured in cst.

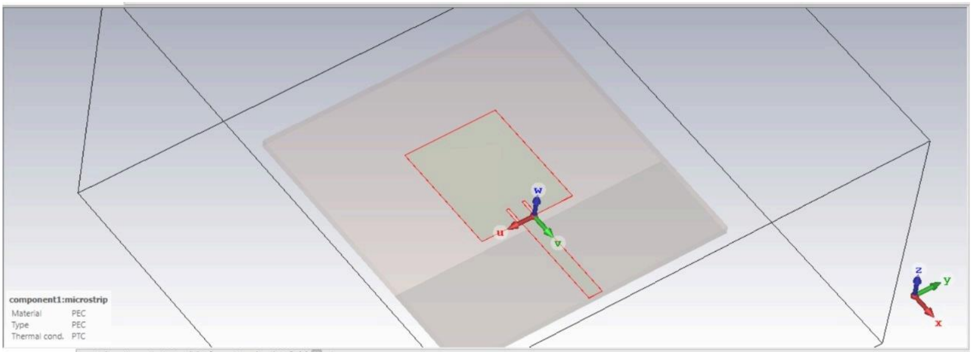

Fig. 3. Design Of Single Element Microstrip Patch Antenna

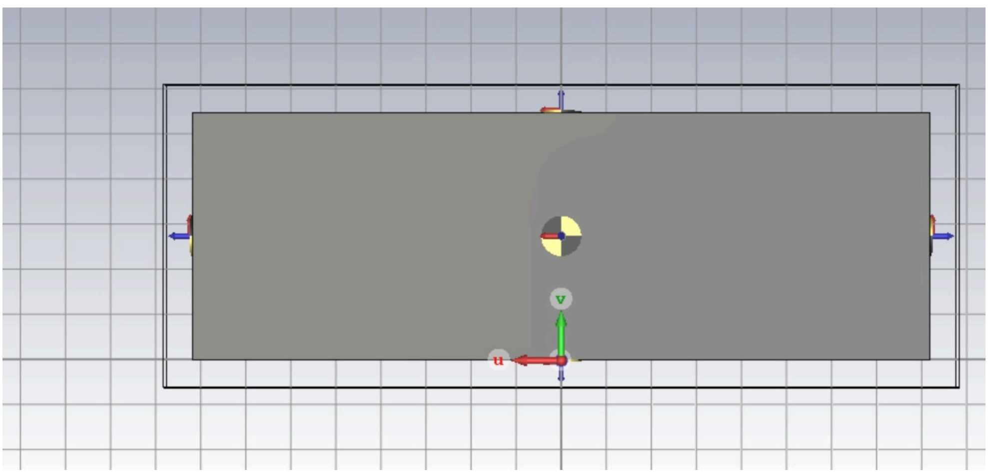

Fig. 4. Back View of Microstrip Array Antenna

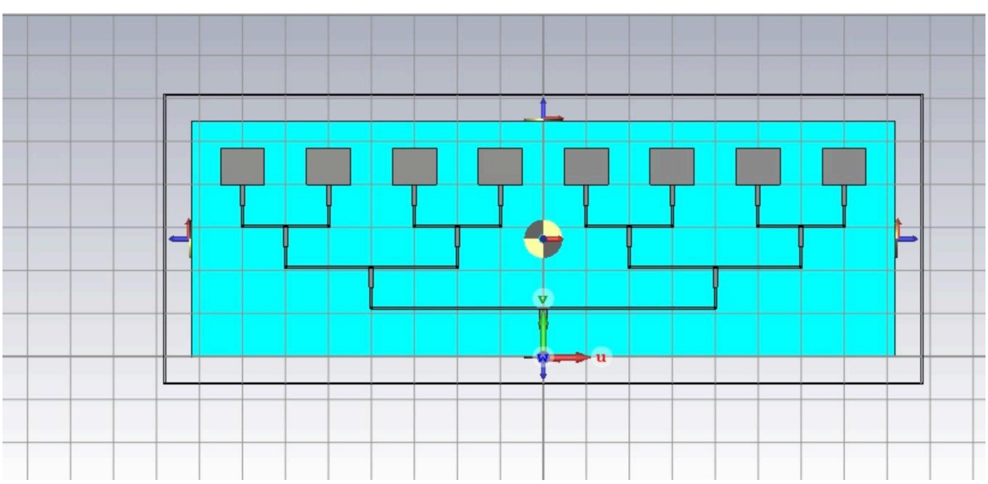

Fig. 5. Front View of Microstrip Array Antenna

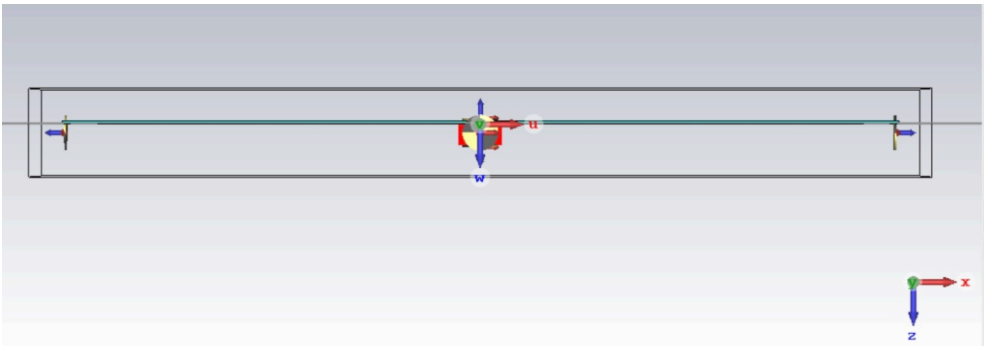

Fig. 6. Top View of Microstrip Array Antenna

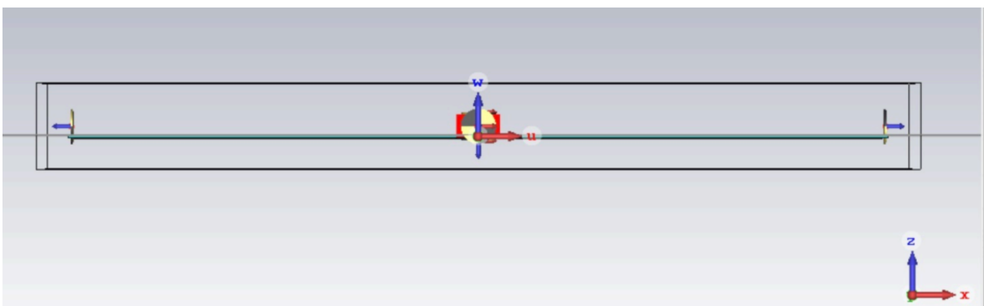

Fig. 7. Bottom View of Microstrip Array Antenna

The following parameters have been considered for the design of Microstrip patch array antenna.

Table. 2. Parameters for Design of Microstrip Patch Array Antenna

Name	Value	Name	Value
line_length_3	23.7327634129003	line_width_6	2.57533841267043
line_length_4	23.7327634129003	matching_line_length_1	23.7327634129003
line_length_5	23.7327634129003	matching_line_length_2	24.0607552251822
line_length_6	23.7327634129003	matching_line_length_3	24.0607552251822
line_width_1	2.57533841267043	matching_line_length_4	24.0607552251822
line_width_2	2.57533841267043	matching_line_length_5	24.0607552251822
line_width_3	2.57533841267043	matching_line_length_6	24.0607552251822
line_width_4	2.57533841267043	matching_line_length_7	24.0607552251822
line_width_5	2.57533841267043		

Table. 3. Parameters for Design of Microstrip Patch Array Antenna

Name	Value	Name	Value
Metal Thickness	3.74740572500001E-02	Feed line length	32.4317225513379
num_ff_monitors	10	Feed line width	2.57533841267043
Num_patches	8	Feed width total	704.530099667017
Patch_length	42.5511098950844	Frequency centre	2.4
Patch_spacing	99.9308193333333	Frequency maximum	2.64
Patch_width	50.9957326968581	Frequency minimum	2.16
Relative_permitivity	2	Line length 1	23.7327634129003
Substrate_height	2.64981600000479	Line length 2	23.7327634129003
Substrate_length	273.324532815237	Line length 3	23.7327634129003
Substrate_width	817.982594447209	Line length 4	23.7327634129003
Tan_delta	0	Line length 5	23.7327634129003
Wavelength_centre	124.913524166667	Line length 6	23.7327634129003
X_centre_outerline	349.757867666667	Line width 1	2.57533841267043
c0	299.792458	Line width 2	2.57533841267043
Feed length total	199.545041878486	Line width 3	2.57533841267043

5 Results

The figures below shows the results of designed microstrip array antenna.

5.1 VSWR

The voltage standing wave ratio evaluates the efficiency with which radio-frequency power delivered from a source to a load over a transmission line.

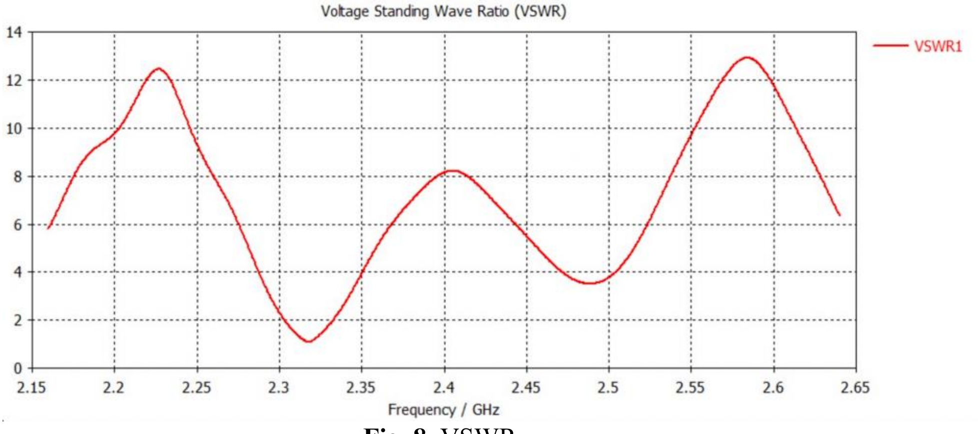

Fig. 8. VSWR

Figure 8 shows the voltage standing wave ratio of array antenna at centre frequency of 2.6 GHZ. The VSWR value is measured as 1.33.

5.2 Radiation Pattern

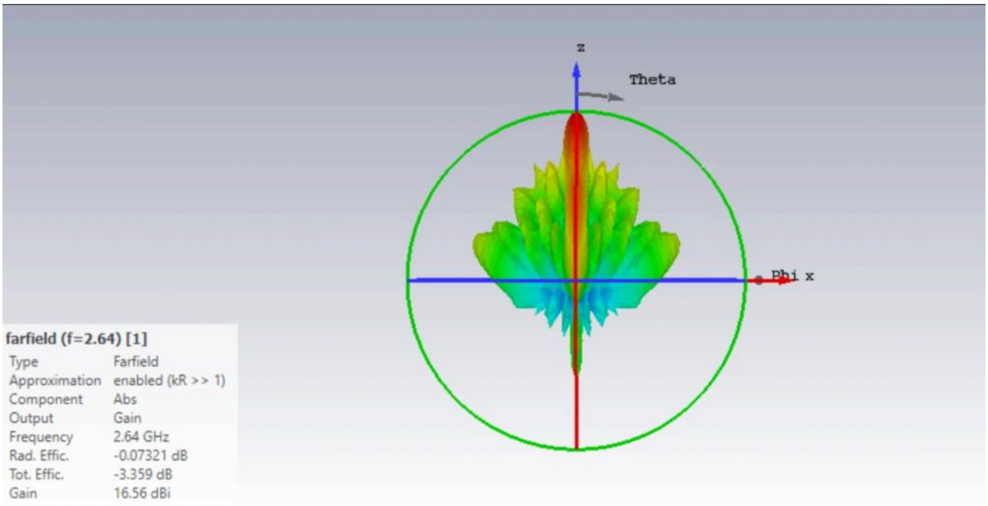

Fig. 9. Radiation Pattern 3D

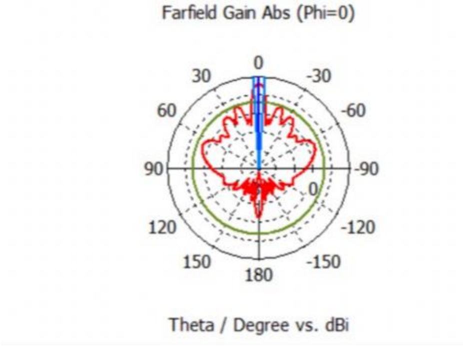

Fig. 10. Radiation Pattern 2D

Directivity is a measurement of the concentration of a radiation pattern in a particular direction, and it’s measured in dB. From fig 9 the gain of array antenna is 16.56 dBi

5.3 S- Parameters

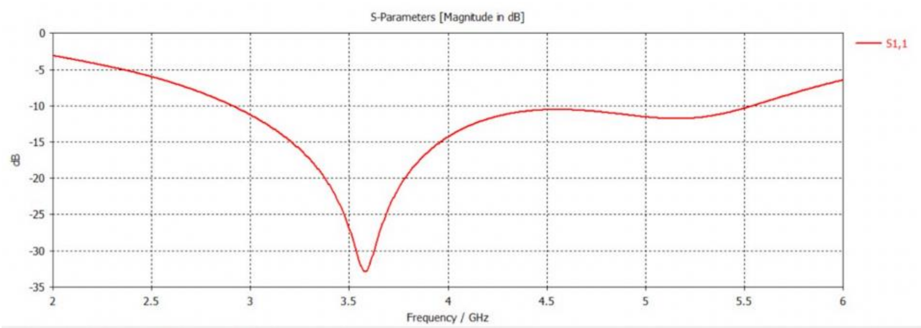

Fig. 11. S-Parameters

6 Conclusion

We proposed a 8x1 Microstrip patch array antenna design and analysed its operational characteristics. A growing number of wireless communication applications are using 8x1 Microstrip array antennas due to their benefits. This study has covered the antenna's design specifications.

References

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