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Development of C-Band Dipole Slot Array Antenna for Multiband Application

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Abstract:

This study presents a small-sized square dipole array slot microstrip antenna for multiband application. This microstrip antenna prototype was modeled using anAnsys HFSS. The 24x24 mm^2 antenna prototype was created with 5.5 GHz and 8.2 GHz frequencies. The frequency range is from 5.2 GHz to 5.99 GHz for the centralized frequency of 5.5 GHz, and the frequency range of 7.96 GHz to 8.61 GHz for the centralized frequency of 8.2 GHz. For all multiple resonant frequencies, the antenna simulation results show good directional patterns, gain plots with effective reflection coefficients, as well as a current distribution from the surface. The suggested microstrip antenna prototype supports application in the WiMAX, C-band, and X-band and can be utilized concurrently for wireless communications.

Keywords **—Array antenna, C-band, 3D polar plot.**

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I. INTRODUCTION

Wireless communication is now a crucial component of many communication systems, achieving long-distance data transmission and reception without the use of a physical. Over the years, wireless communication technology today result in an antenna that is small, flexible, affordable, and simple to make. Wi-Fi communication devices, weather radar systems, and satellite communication between ground stations can all benefit from the C-band.[1][2]

WiMAX technology was developed to easily deliver leased broadBand digital services to both residential and business customers in order to achieve long-distance communication over kilometres of range. It would support image and video transmission for a huge number of user controls, operating at faster speeds with higher bandwidths over greater distances. Compared to wired communication, WiMAX systems are better able to overcome obstacles and offer internet service to remote locations. An antenna's large size and lower cost are major drawbacks in meeting WiMAX requirements for wide coverage [3] - [5].

Microstrip antenna were created to address the issues with directional radiation patterns and dual-band circular polarization. They are essentially low-profile, high-gain antennas.Consequently, a variety of fundamental antenna types with gain, return loss, radiation pattern, and surface current distribution analyses were presented [6] – [8].

Earlier in the development of wireless communication, the federal communications commission initially proposed allocating the C-band frequency spectrum from satellites to commercial telecommunications. Synthetic aperture radars use the C-band frequency spectrum and moving target indicator radars offer high-resolution images of the target for identification[9].

In the past, the main goal of microstrip antennas was to reduce cross-polarization, and they mainly concentrated on single antenna elements. Later, antenna array elements with slot array antennae were taken into account to suppress cross polarization over 10 dB to 15 dB primarily in the horizontal plane. As a result, more than 25 dB isolation between co-polarization and cross-polarization in the primary planes as well as suppressing mutual coupling caused by surface waves due to impedance mismatch between transmitter and receiver were observed[10].

II. ANTENNA DESIGN

A. Evolution process of microstrip antenna

Below, Fig. 1 represents the step-by-step process of microstrip slot array antenna.

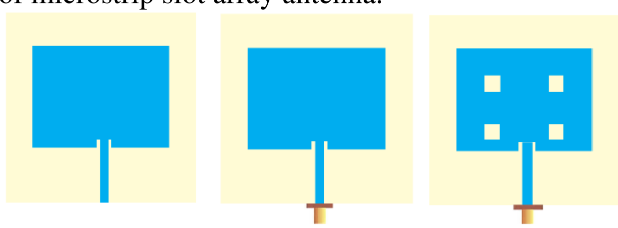

Fig. 1 Antenna evolution process

B. Microstrip antenna with dipole slot array

Square dipole slot array proposed microstrip antenna prototype was depicted on ROGERS 4350 material with dielectric constant and loss tangent as 3.48(ε_r) and (δ) 0.0037. Now the length(L_1), width (W_1) along with height (h) are the dimensions of ROGERS 4350 material.

Width of patch: $W = \frac{C_o}{2f_r}\sqrt{\frac{2}{\varepsilon_r}}$ (1)

Length of patch: $L = \frac{C_o}{2f_r\sqrt{\varepsilon_r+\varepsilon_{air}}} - 2\Delta L$ (2)

Height of substrate: $h \leq 0.05\ \lambda_0$ (3)

A radiating copper material that is in rectangular shape and metalized on the ROGERS 4350 substrate material with length(L_2) and width (W_2) respectively. An array of square dipole slots was etched from the copper material with the dimensions length(L_3) and width (W_3) and the between each slot is length(L_4) and width(W_4) is shown.

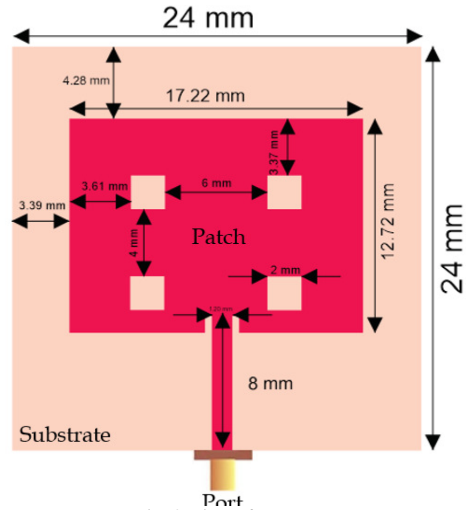

Fig. 2 View of prototype antenna

Effective dielectric: $\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{w}\right]^{1/2}$ (4)

Change in patch length: $\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{w}{h}+0.8\right)}$ (5)

A line feeding technique with an input impedance (Z_i) of 50 is fed through radiating copper material. Dimensions of line feeding are length (L_5) and width (W_5), which is shown above in Figure 1, and the dimension of the prototype antenna were mentioned in Table 1.

TABLE 1

Design Parameter	Optimum value(mm)
Length of the substrate	24
Width of the substrate	24
Length of the patch	17.22
Width of the patch	12.72
Length of the slot	2
Width of the slot	2

Length between the slots	6
Width between the slots	4
Length of the transmission line	1.2
Width of the transmission line	8

III. RESULTS OF MICROSTRIP ANTENNA

C. *Reflection coefficient(dB) of antenna prototype*

The square shaped dipole array slot microstrip antenna analysis has been carried out by using HFSS 16.0 simulator software and the antenna was resonating at a frequency 5.5 GHz, reflection coefficient is -24.0926dB. Figure 2 depicts reflection coefficient for prototype microstrip antenna suitable in WiMAX and C-band application. This is when the substrate FR4 material is used.

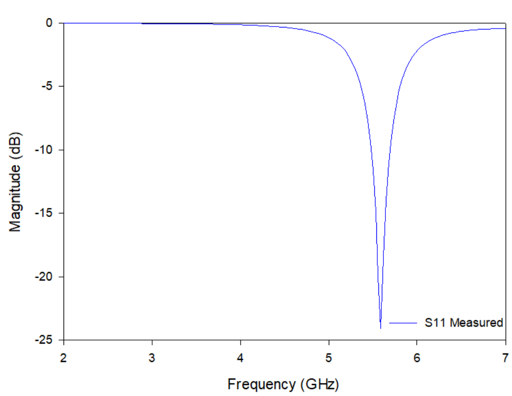

Fig. 3 Reflection coefficient(dB) for C-band

When the substrate Rogers 4350 is used it show the multiband, C-band 5.5 GHz and X-band 8.2GHz of magnitude -24.0926 dB and -22.2412dB.

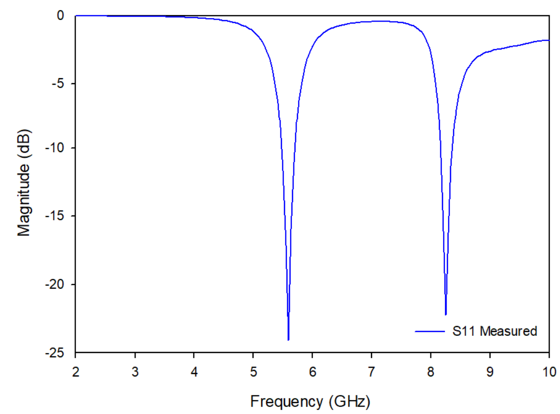

Fig. 4 Reflection coefficient(dB) for C-band and X-band

D. *Radiation pattern for square array slot microstrip antenna*

Below, Fig. 6 represents the antenna direction of radiation plots. Directional pattern contains radiation properties with respect to spatial coordinates. It includes the intensity of radiation, strength of electric field or magnetic field, directivity of antenna, polarization properties of antenna.

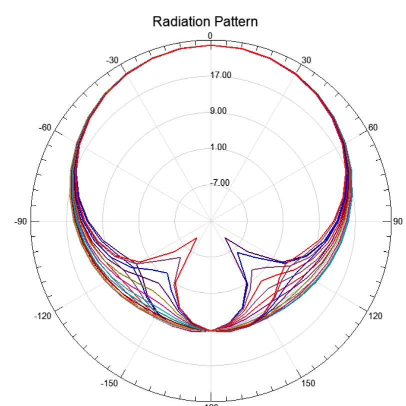

Fig. 5 Radiation patterns for array slot microstrip antenna

E. *3D-Gain plots of slot array antenna*

Fig. 6 shows 3D Gain plot for microstrip antenna and maximum gain was observed at 5.5

GHzfrequencywith 6.3863dB.

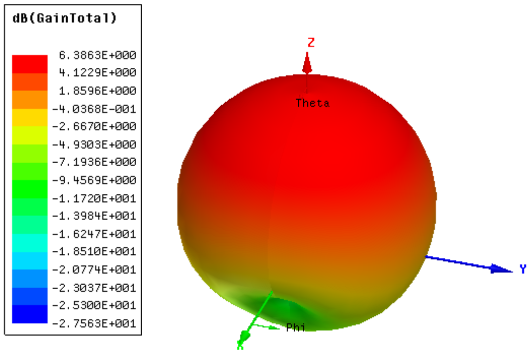

Fig. 6 3D Gain plot for dipole slot array antenna at 5.5 GHz

F. Surface current distribution for square slot array antenna

Current distribution for microstrip antenna at frequency 5.5 GHz. The figure shows the current density and flow of e^- field movement inside the proposed antenna along with density meter.

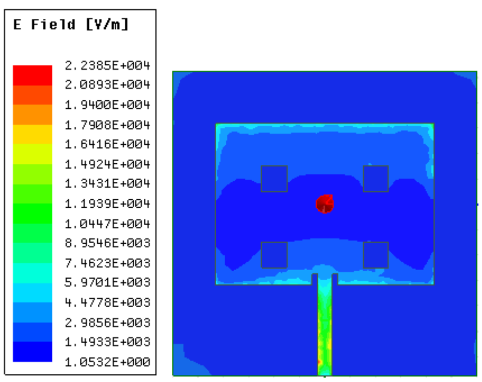

Fig. 7 Surface current distribution for square slot array antenna at 5.5 GHz

IV. CONCLUSION

A compact multiband square-shaped array slot antenna has been carried out by Ansys HFSS_16.0 simulator software with a total size of 24x24x3 mm^3. The microstrip antenna resonates at two resonant frequencies which are 5.5 GHz and 8.2 GHz. The proposed microstrip patch antenna covers the C-band and X-band. The application are satellite communications transmissions, Wi-Fi devices, cordless telephones as well as surveillance and weather radar

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