A Wideband Rectangular-slot Microstrip Array Antenna for Wireless Applications

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Abstract—This paper presents the design of a 2 x 2 microstrip array antenna suitable for wireless applications. The proposed antenna comprises of 4 rectangular patches where diagonal patches have the same length and width. A larger bandwidth and the desired resonant frequency are achieved because of a reduction in the quality factor (Q) of the patch resonator, which is due to less energy being stored beneath the patch due to the rectangular arrangement of the slots. The characterization results of return loss, gain, and radiation pattern are presented consecutively. From the results, the simulated impedance bandwidth defined for S11<-10dB reaches 1850MHz (4.69-6.54GHz) representing 16.47%.

Keywords—wideband, array antenna, slot, patch, wireless

I. INTRODUCTION

MICROSTRIP antennas have been popular for decades because they exhibit a low profile, small size, lightweight, low manufacturing cost, high efficiency, and an easy method of fabrication and installation. Furthermore, they are generally economical to produce since they are readily adaptable to hybrid and monolithic integrated circuits fabrication techniques at radio frequency (RF) and microwave frequencies [1]. One of the most important disadvantages of microstrip patch antenna is their narrow bandwidth. To overcome this problem and for the antenna to work within a stipulated band, a number of methods and structures have recently been proposed. Mention can be made of wideband aperture coupled microstrip array antennas [2], U-slot with proposed π-shaped stub [3], double rectangular patch with bridges [4], stacked layered structures [5], resonator antennas with capacitive coupled parasitic patch element [6], circular edge truncation [7].

This paper presents a wideband 2 x 2 rectangular slot microstrip antenna which covers the WLAN band. WLAN takes advantage of license free frequency bands, industrial, scientific, medical (ISM) bands and uses one of frequency band 5.15 to 5.825 GHz (IEEE 802.11a) [8]. Since WiMAX has three allocated frequency bands called low band (2.5 GHz to 2.8 GHz), middle band (3.2 GHz to 3.8 GHz), and high band (5.2 GHz to 5.8 GHz), the proposed antenna is also applicable to WiMAX. The impedance bandwidth in percentage is 16.47% which is far higher than that of [4] who compared double rectangular patch with 4 bridges for 2.4GHz and 5.5GHz WLAN applications.

It also has a higher bandwidth than [8] and [9] who recorded 14% for WiMAX and 14.1% for WLAN applications respectively.

II. ANTENNA CONFIGURATION

Fig. 1 depicts the structure of the 2 x 2 rectangular slot microstrip array antenna which comprises of three layers, including top, middle, and bottom layers. The radiating elements are on the top layer, the middle layer is a metal ground with rectangular slots and the bottom layer consists of a microstrip feed line. The bottom layer is between the feed line and the metal ground. The top layer is between the radiating element and metal ground.

![Fig. 1 Configuration of the 2 x 2 microstrip array antenna elements](image)

In this design, a material with a permittivity \( \varepsilon_r2=2.2 \) and \( \varepsilon_r1=1 \) are chosen as the top and bottom materials respectively, with same height of 0.8mm. It is noted that the sizes of all substrates and the ground plane are the same (50x50mm\(^2\)). The radiating elements A has a size of 7.5x11mm\(^2\) whiles that of B has a size of 9x11mm\(^2\) as shown in Fig. 1. The arrangement of the slots on the ground plane accounts for the double frequency resonance, that’s 5.23GHz and 6.31GHz. The spaces between the radiating elements are set at 20mm for better radiating characteristics. The rectangular arrangement of the slots in the ground plane has a size of 3x7mm\(^2\) and spaced 10mm apart. To obtain the desired radiation pattern with its associated characteristics, a 2x2 planar microstrip slot array antenna is designed. The bottom substrate consists of the microstrip feeding network which is designed to give equal amplitude and phase to each element where it is matched to a 50 ohms feed line.

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III. RESULTS

The array antenna is simulated using the commercial Ansoft HFSS design software. Fig. 2 shows the simulated return loss of the proposed antenna. The simulated impedance bandwidth defined for S11<-10 (VSWR) reaches 1850MHz (4.69-6.54GHz) which covers the 5.15-5.95GHz WLAN and WiMAX bands. There is a double frequency resonance which is primarily due to the arrangement of the slots on the ground plane. Fig. 3 shows the radiation patterns for Phi, Theta = 0 degrees and Phi, Theta = 90 degrees at both resonant frequencies (5.23GHz and 6.31GHz). We can also find from Fig. 3(a) and (b) that the half-power beam width (HPBW) is 60° in both E and H planes at 5.23GHz, in Fig 3(c), HPBW is 60° in the E plane and 62° in the H planes. Similarly, in Fig. 3(d) HPBW is 60° in the E plane and 58° in the H plane.

IV. OPTIMIZATION

Since radiating element is the basis of antenna array and its form determines the realization and electrical performance of antenna array, it is necessary to investigate the influence on the element antenna due to the structure parameters.

Optimization about the size of the patch is showed in Fig. 4(a), 4(b), 4(c) and 4(d). As the width of patch A is varied, the 6.31GHz resonance decreased considerably, increasing that of the 5.23GHz resonance to more than -50dB. When the length of the patches takes a small change, it will have great influence on the resonant frequency. So the effects on resonant frequency due to the length of the patch should be paid attention to. Different resonant resistances of the patch antenna can be realized through the variation of width of the patch. Optimization about the size of the slot is shown in Fig 4(e) and 4(f). The resonant frequency decreases when the length of the slot of reduced and changes when the length is increased. Meanwhile the resonant resistance increases significantly and the coupling strength increases. The length of the slot cannot be set too long, or it will enhance the backward radiation. But if the length of the slot is too short, it cannot ensure enough coupling. The width of the slot has the same performance as well as the length. But the width usually is limited below a very small value for decreasing the backward radiation. So the length rather than the width is adjusted in the design process. Fig. 4(g) shows the return loss when the slots are removed. It can clearly be seen that the slots plays an important role in widening the bandwidth.
Fig. 4 Parameter Optimization (a), about width of patch B (b), about length of patch B (c), about width of patch A (d), about length of patch A (e), about length of slot (f), about width of slot (g) about without slot

V. CONCLUSION

A rectangular slot 2 x 2 microstrip array antenna has been proposed where the simulated impedance bandwidth defined for S11<-10dB (VSWR) reaches 1850MHz (4.69-6.54GHz) representing 16.47% has been achieved. The proposed antenna can be used for wireless applications such as WLAN and WiMAX.

VI. REFERENCES


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Obeng Kwaye Kingsford Sarkodie (S’14) was born in Kumasi, Ghana in 1986. He received the B.S degree from the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana in 2009. He received the M.S degree from the University of Electronic Science and Technology of China in 2012, where he is currently working toward the PhD degree. Prior to his continuing education at the University of Electronic Science and Technology of China, he was a teaching assistant at the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

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