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DESIGN AND SIMULATION OF MICROSTRIP PHASE SHIFTER FOR ARRAY ANTENNA

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Abstract

Printed dipole antenna array with beam steering capability in fixed direction for 2.4GHz (S-band) is presented. Design uses printed dipole antenna with integrated balun as an array element. For this array a compact, planar, low cost microstrip meander line phase shifter is designed which has differential phase shift of 150^o. The array comprises of 4×1 microstrip patch printed dipole array. The array elements are excited by the Wilkinson equally split 1×4 power divider followed by the phase shifter. The designed elements are simulated using HFSS v13 individually. The FR4 epoxy substrate with 4.4 relative permittivity and 1.6 mm thickness is used to fabricate array elements.

Keywords*—2.4GHz ,diversity, printed dipole, phase shifter, power divide etc.*

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1. INTRODUCTION

In recent years the number of applications of wireless network increases exponentially, such as mobile phone users, personal wireless network, Wi-Fi, etc. In cellular communication it is essentially need to increase the capacity, range and reduces the co-channel interferences within available bandwidth. Modern wireless network demands for cost effective, flexible, compact, simple antenna design. Microstrip patch technology provides all these advantages [1]. The only drawback of microstrip patch technology is that it has low gain and narrow bandwidth. Phased antenna array provides the high gain, the increased spectral efficiency and increased signal to noise ratio. It has ability to track multiple users at the same time. This makes them very popular in the field of WLAN applications. Therefore various techniques are developed for beamforming and beam steering such as variation in the phase, amplitude or both phase and amplitude of feed signal antenna array elements [2]. In order to develop phased array antenna network a planar dipole antenna with integrated balun at back side of patch with microstrip line feeding method is proposed. The microstrip meander line phase shifter is designed to provide phase shift of 150^o .

2. SYSTEM DESIGN

The blockdiagram of the system is as shown in Figure 1 and the simulation of the system as per design is as shown in Figure 2. A brief discription of system block along with design procedure is as given below

2.1 ANTENNA

Antennas play an integral part in wireless communication system. microstrip patch antennas are versatile in terms of their geometrical shapes and implementations. Inhibiting characteristics of a single microstrip patch, like low gain and smaller bandwidth, make it more popular for array configuration. In the system design four printed dipole radiating antennas have been fabricated on separate low dielectric constant substrate and arranged in linear configuration to achieve the required radiation properties. Thus by using 4×1 array in the system we can enhance the performance of the antenna like increasing gain,directivity,scanning the beam of the antenna system and other functions which are difficult to do with the single element.

2.2 PHASE SHIFTER

Phase shifters are components of electronically scanned array that steers the antenna beam in the desired direction without physically reposition the antenna. Phase shifters are classified as mechanical phase shifters, ferrite phase shifters, semiconductor device phase shifters and transmission line phase shifters. The transmission line phase shifter is designed in the present system.

2.3 POWER DIVIDER

Power dividers are used for splitting microwave signals to feed the radiating elements. Themicrostrip array feeder network, consists of Wilkinson power divider and phase shifters. The four-way power splitter using Wilkinson type power dividers improves the isolation and matching of the ports. The antenna array is designed using standard equations and simulated by professional software called, High Frequency Structural Simulator (HFSS) version13.

2.4 DESIGN OFDIPOLE ANTENNA

The printed dipole antenna is simulated using on FR4 substrate with thickness h = 1.6mm and permittivity εr = 4.4 in HFSS. The length of dipole arm is approximately equals to the quarter wavelength. The microstrip dipole antenna is simulated with the designed parameters as given below.

Pcb substrate: FR4 (thickness h=1.6 mm, ε_r =4.4)

dipolearm :length L1=20 mm, width W1=6 mm, gap g=3 mm,W3=5 mm,L3=11mm,L4=8mm.

Microstripbalun: length L2=29 mm ,L5=6 mm,W3=3 mm

via hole: radius=0.375 mm, height 1.6 mm

ground plane: W4=70 mm

2.5 PHASE SHIFTER DESIGN

By varying the length of the microstrip line we can obtain the desire phase shift. For that following calculation are needed

$$\phi = \beta l = \sqrt{\varepsilon_r} k_0 l \quad \textbf{(1)}$$

$$k_0 = \frac{2\pi f}{c} \quad \textbf{(2)}$$

ϕ is the phase shift , l is the length of the transmission line, β is propagation constant and ε_r is the dielectric effective constant. For 150^o phase shifter length is 100 mm and width is 3mm.

2.6 DESIGN OF POWER DIVIDER

The input impedance Z_0 of proposed power divider is $50\,\Omega$ .Therefore the arm impedance is $\sqrt{2}Z_0$ i.e. 70.71 Ω.The length of the power divider arm is equal to the $\lambda/4$.Finally the value of the arm resister is $100\,\Omega$.

3. RESULTS

Since the antenna is design to operate at a frequency of2.4 GHz, the reflection response of the antenna was observed for a frequency range of 1GHz to 3GHz as shown in Figure 3. It is evident from the graph that antenna is resonating at 2.3 GHz which is very close to the operating frequency 2.4GHz. Also S_{11} is -11dB value, illustrated in the Fig.3 demonstrate a goodimpedance at the resonating frequency. The 3dB bandwidth of the device is calculated to be approximately 3%.Radiation patter shows that the antenna radiates equal energy in all direction as shown in Figure 4. The simulated result gives satisfactory performance within specified range.

For designed phase shifter the value of insertion loss has been observed to nearly -1dB and return loss is below -20dB i.e. -0.92 dB and -22.40 dB at 2.4GHz respectively. The simulated results as shown in Figure 5. This microstrip phase shifter provides a phase shift of 153^o as shown in Figure 6.

The radiation pattern as shown in Figure 7 and Figure 8clearly shows the phase shift in the main antenna beam. We provides the phase shift of 150^o then there is beam shift of 140^o is observed. Hence it is clear that the microstrip phase shifter for array antenna works as per design.

CONCLUSION:

The micro strip phase shifter for array antenna has been sucssesfully designed and simulated which have many advantages like compact structure, low cost and fair accuracy. It can be used for many applications WLAN, PAN etc.

4. FIGURES

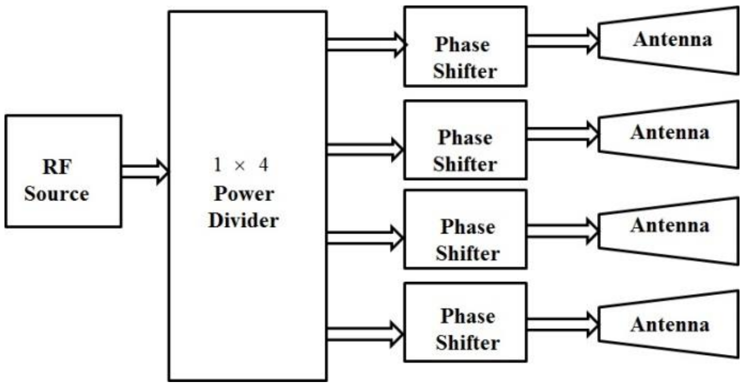

Figure 1 System block diagram

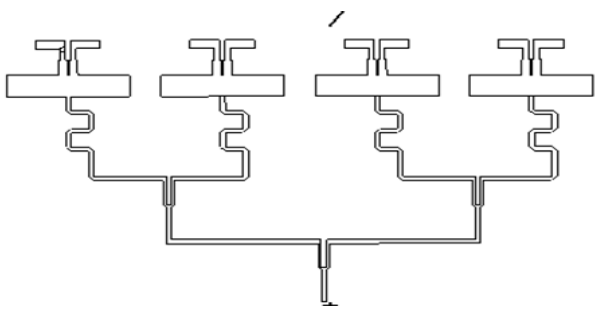

Figure 2 Simulation of System

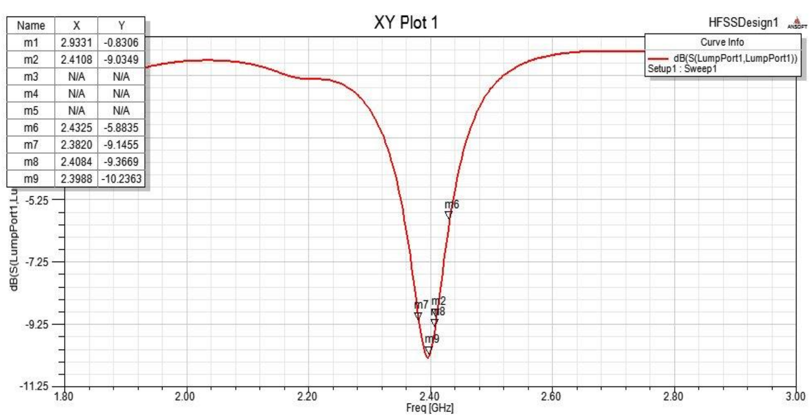

Figure 3 Return loss of dipole antenna

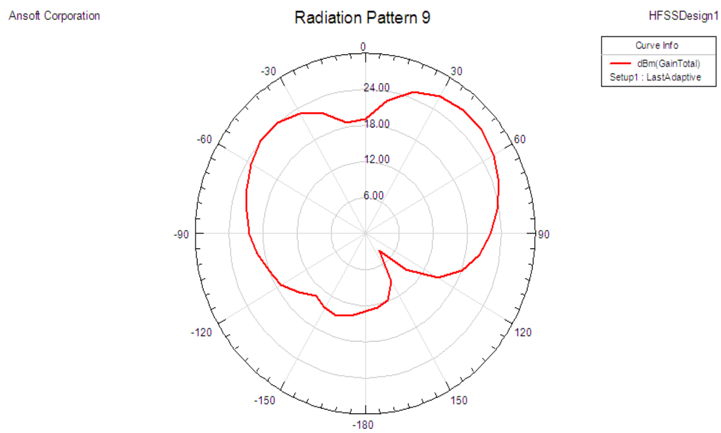

Figure 4 Radiation pattern of dipole antenna

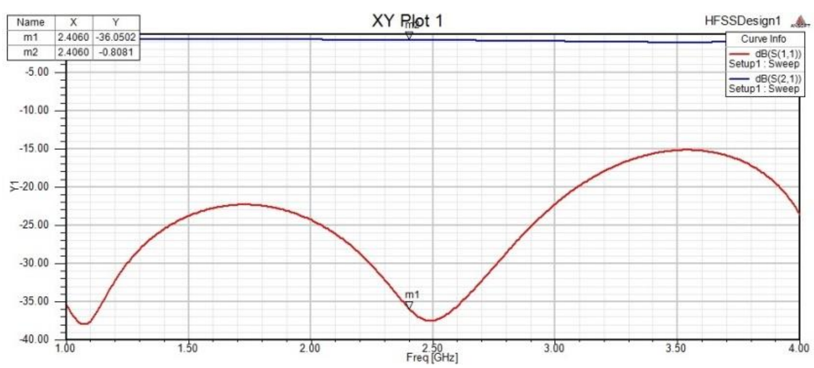

Figure 5 Return loss and insertion loss of phase shifter

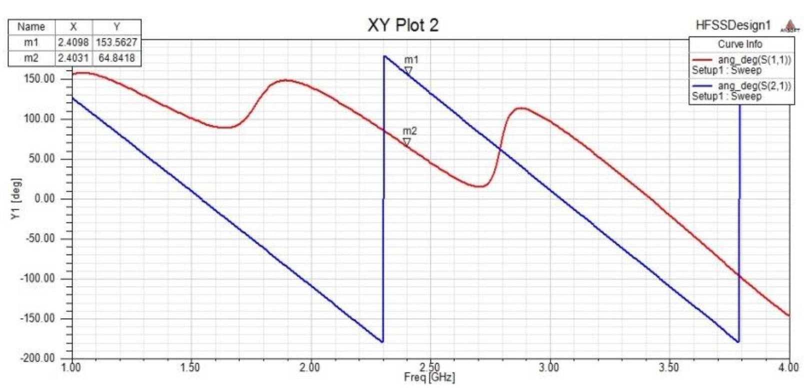

Figure 6 Phase response of phase shifter

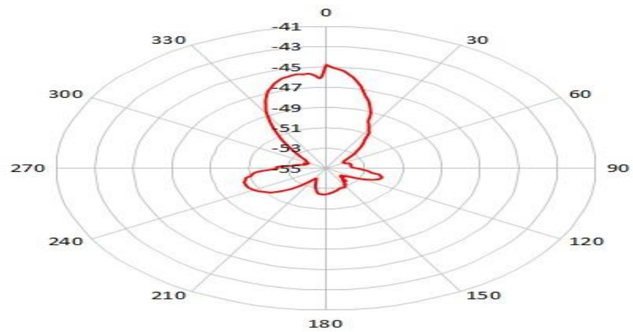

Fig.7 Radiation pattern of array

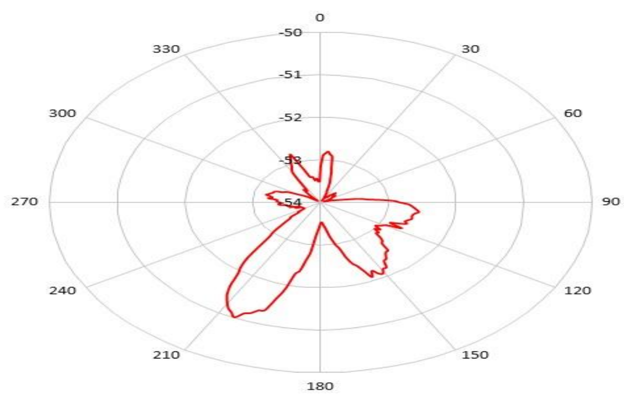

Figure 8 Beam shifting

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