DUAL POLARIZATION SINGLE PORT INSET FEED MICROSTRIP PATCH ARRAY ANTENNA

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Abstract

This paper present the designs of array antenna from type of inset-fed microstrip patch antenna by using single port oriented at 45° and -45°. The antennas are capable to generate dual-polarization radiation pattern centered at 45° and -45°. Combinations of two patches using quarter-wave impedance matching technique has been used to designs the array antennas operate at 2.4 GHz. The designs are simulated using Microwave Office 2004 and were fabricated on FR4 substrate with a dielectric constant ε_r =4.7, tan δ =0.019 and thickness =1.6mm. The simulation and measurement result have been compared. The 3 design 1x2 array antennas yield a bandwidth greater than 5%. The gain of the proposed antennas is also stable with operated frequency. The result showed that the combination of more patches in array can improve the return loss and gain performances.

Keywords: *Dual polarized, inset feed, microstrip antenna, patch antenna.*

I. INTRODUCTION

IN various application of dual polarization antenna, the microstrip antenna element has offers three excellent advantages relative to other types of antennas [5]-[7]; low weight, low profile with conformability and low manufacturing cost. Recently, in many wireless communication and radar system, a dual polarized is greatly desired. In practices, a dual-polarized microstrip antenna can be realized by feeding the rectangular microstrip patch at two orthogonal edges, through edge feed or probe feed, which excites TM01-and TM10-mode with orthogonal polarizations [1]–[4]. Both the element itself and its array often achieve isolation of about -20dB [1]–[3].The most reported technique for achieving dual polarization is using different feed mechanisms such as aperture-coupling a single patch with crossed narrow slots or two offset narrow slots [5]. This technique requires a relatively complicated feed arrangement [6] or a complex multiplayer construction [7] to reduce the coupling between the two feed lines and therefore adds complexity to the fabrication process.

In this letter, the design of inset fed microstrip antenna is proposed at 45° and -45° to achieve the optimum performance of the return loss, antenna gains and polarization loss. A design of the broadband dual-polarized microstrip antennas is proposed by using the simply inset feed technique but slant at desired rotation. In most applications, the requirement of propagation can be met with a single patch structure. However, in some cases, sharp beamwidth was required, as well as maintaining a low profile structure, which arise the development of microstrip patch array antennas. Both design of array antennas in this paper were connected using parallel feed quarter-wave transformer impedance matching technique.

II. DESIGN PROCEDURE

Corresponding to the optimum design, an antenna has been fabricated and tested. Details of the antenna design and its measured performance are presented and discussed. There were several ways to design microstrip antennas such as transmission line, inset fed, proximity and aperture models. Details of the designed broadband dual-polarized microstrip antennas is proposed by using the inset feed technique [9].The parametric study on the single patch antenna is done first to understand the characteristics of the antenna. Fig. 1 and Fig. 2 showed the dimension of the 45° and -45° single patch antennas.

Fig. 1: Layout of the 45° polarized patch antenna

Fig. 2: Layout of the -45° polarized patch antenna

This paper is focusing on the combination of the same antenna to obtain a better response by developing the arrays. For this project, a parallel or corporate feed configuration was used to build up the array. In parallel feed, the patch elements were fed in parallel by using transmission lines. The transmission lines were divided into two branches according to the number of patch elements. The quarter-wave transformer impedance matching technique was applied to divide the power equally to all patches.

The impedances of the line were translated into length and width by using Microwave Office 2006. Figure 3 show the circuit layout of 1x2 array antennas. This design can produce better high gain and broadband compared single element. The position of the patch antenna is oriented at 45° and -45° to obtain dual- polarized radiation.

The design of 2x2 and 1x4 and 2x4 array antennas also has been investigated. In both design, the improvement of return loss, VSWR, and antenna gain was investigated. The feeding type of 2x2 and 2x4 array antenna is using coax probe. Whereas, the 1x2 and 1x4 array antenna are using quarter wavelength transmission line feeding technique.

Fig. 3: Fabrication design of 1x2 array antenna

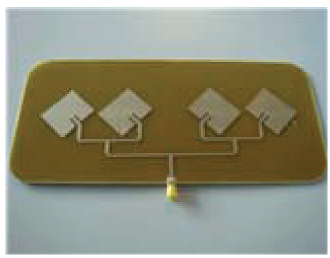


Fig. 4: Fabrication design of 1x4 array antenna

Fig. 5: Fabrication design of 2x2 array antenna

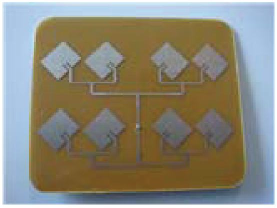


Fig. 6: Fabrication design of 2x4 array antenna

III. SIMULATION

Once, all physical dimensions have been calculated, the design would then be simulated by using Microwave Office 2006 software to simulate the return loss, radiation pattern, and VWSR of the antenna. The simulation results for dual polarized 1x2 array antennas were 1.376 and -17.66 dB for VSWR and return loss respectively. While, the simulation result for dual polarizations 1x4 array antennas were 1.370 and -22.33 dB. Fig. 7 and 8 shows that the combination results of 1x2, 1x4 and 2x2 array antennas. All simulation data are tabulated in Table 1. Again, this proves that the combination of more patches in the array antenna can improve the return loss and better high gain performances.

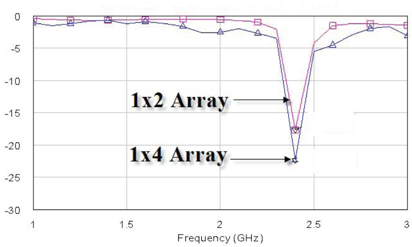


Fig. 7: Return Loss [dB] for 1x2 and 1x4

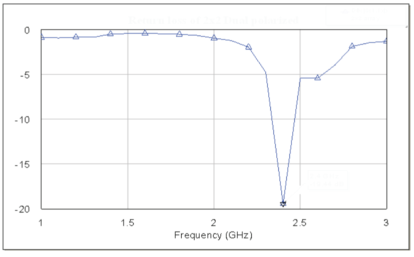


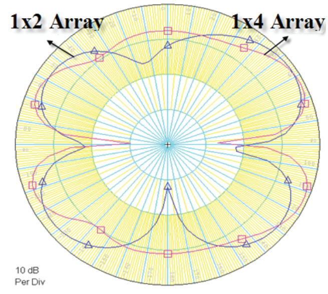
Fig. 8: Return Loss [dB] for 2x2 array antenna

Table 1 show the simulation result for basic antenna parameters of dual polarized antenna design. All dual polarized antenna have been design at 2.4 GHz resonant frequency and return loss lower than – 10 dB for 90% radiation efficiency. The return loss and bandwidth of dual polarized antenna was improved when more patch element is used.

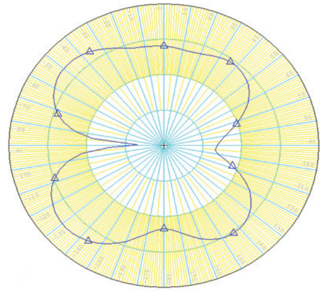
Table 1: Simulation result for dual polarized array antenna

	Dual Polarized Antenna Array			
	1 x 2	1 x 4	2 x 2	2x4
Resonant Freq (GHz)	2.4	2.4	2.4	2.4
Return loss (dB)	-17.60	-21.08	-19.4	-32.34
VSWR	1.35	1.37	1.24	1.41
BW (%)	4.42	4.41	5.46	7.08

Fig. 9 (a) had shown the combination of radiation pattern simulation result for 45°and -45° polarizations 1x2 and 1x4 array antennas, respectively. Fig. 9 (b) show the simulation results for 45° and -45° dual-polarized 2x2 array antennas radiation pattern at the resonant frequency.



(a)



(b)

Fig. 9: (a) Radiation Pattern for 1x2 and 1x4 Dual Polarized Array Antennas. (b) Radiation Pattern for 2x2 Dual-Polarized Array Antenna.

IV. MEASUREMENT RESULTS

The same parameters involve in the simulation were measured using Advantest R3767 CG Network Analyzer. The return loss is below -10 dB within the frequency range between 2.4-2.61 GHz, corresponding to a bandwidth of 4.22%. For the measurement setup of radiation pattern, the reference of transmitter is using monopole antenna. Figure 10 and 11 shows the radiation pattern measurement for 45° and -45° polarized patch antenna respectively. In this condition, the two planes are considered here at an element plane location 45° and -45°. The element plane designates E-plane for location 45° and H-plane for location -45°. The cross-polarization for both elements is perpendicular to the others.

The 45° polarized patch antennas will generate linear electromagnetic field radiation with principle plane at angle 45°. Similarly, the linear electromagnetic field radiation at principle plane of -45° is generated from -45° polarized antennas. This principle plane can be seen from the direction main lobe angle in radiation pattern.

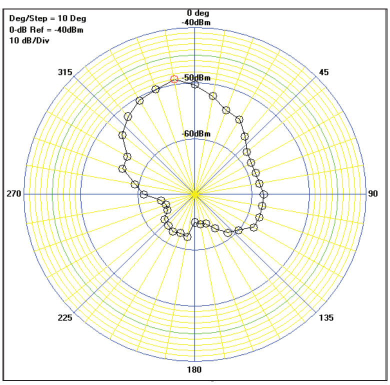


Fig. 10: Radiation pattern for 45° polarized patch antenna

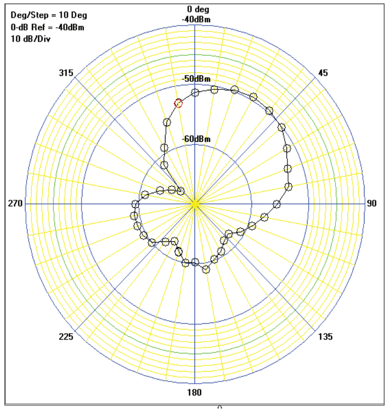


Fig. 11: Radiation pattern for -45° polarized patch antenna

Figure 12 and 13 shows the return loss measurement result for dual polarized antenna. The resonant frequency has shift for 0.04 GHz to 0.15 GHz at the left side. This may be due to dielectric permittivity of the substrate is not uniform at 2 GHz frequency band. However, the return loss of the dual polarized antenna seems improved when more patch element is used.

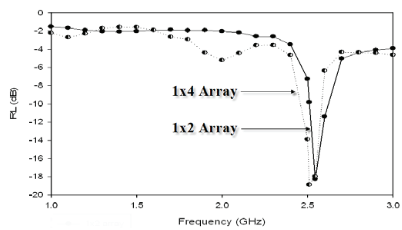


Fig. 12: Return Loss [dB] for 1x2 and 1x4 array.

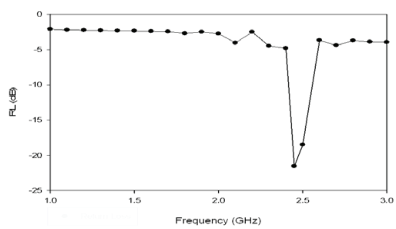
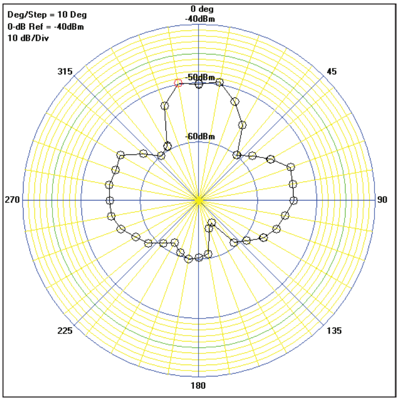


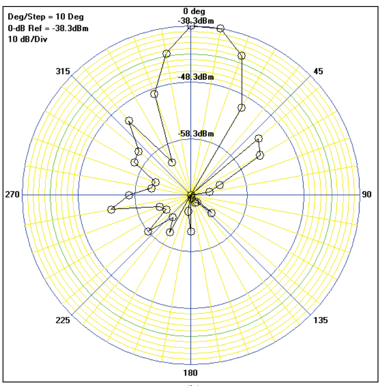
Fig. 13: Return Loss [dB] for 2x2 array antenna.

Figure 14 shows the radiation pattern measurement result for dual polarized antenna. The main lobe for all dual polarized antennas can be seen at 0° angles. This is cause by the mutual coupling from both patch element of

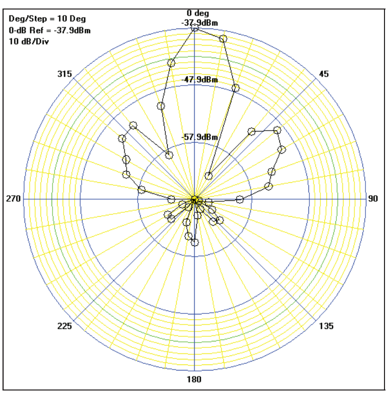
45°and -45°. When, more elements is used, the directivity of the mutual main beam will also increase.



(a)



(b)



(c)

Fig. 14: (a) Measured radiation pattern of 1x2 patch array antenna (b) Measured radiation pattern of 1x4 patch array antenna (c) Measured radiation pattern of 2x4 patch array antenna

However, the principle plane of 45° and -45° lobes also exist at their respective plane. So, the dual linear polarized is exist and radiate from its respective patch element. The mutual coupling effect can be reduce by using greater spacing between 45° patch elements and -45°patch elements.

The gain of the single element antenna almost 2.2 dB and the gain of 1x2 arrays is 2.9 dB. By designing more patch, which is 2x2 and 1x4 array antennas, the enhancement of gain is achieved were 3.1 dB and 4 dB, respectively.

Tables 2 show the comparison results between simulation and measurement. This tables show the values were slightly different. However the antennas still operate at resonant frequency around 2.4GHz with low VSWR. The VSWR and return loss have been observed for both single and 1x2 patches array antenna.

Table 2: Comparison between simulation and measurement result for dual polarized array antenna

	Dual Polarized Array Antenna					
	1 x 2		1 x 4		2 x 2	
	Sim	Meas	Sim	Meas	Sim	Meas
Freq (GHz)	2.4	2.54	2.4	2.51	2.4	2.48
RL (dB)	-17.6	-17.3	-21.1	-18.2	-19.4	-21.3
VSWR	1.35	1.18	1.37	1.16	1.24	1.17
BW(%)	4.42	3.45	4.41	4.77	5.46	3.61

V. CONCLUSION

It can be concluded that the responses from the 1x4 patches were better compared to the 1x2 array antenna and single patches antenna. Although the results from the measurement were not exactly same as in the simulation, it was still acceptable since the percentage error was very small due to the fabrication process has been done manually.

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