

Small-Size Circular Patch Antenna Using a Cross Slot With Unequal Slot Lengths

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Abstract-Circularly polarized waves can be obtained from patch antennas when a square patch is excited by two feeds, with their inputs having a 90° phase shift. A new, circularly polarized small-size micro strip antenna using a proximity coupled feed method is proposed. A simple configuration based on a cross slot with unequal slot lengths on a circular patch is adopted to realize a small-size element antenna. The proposed antenna has no 90° hybrid coupler for circular polarization. The measured results verify the circular polarization, and the antenna radius was reduce by about 22% by using the slot lengths which are nearly equal to the diameter of the circular patch antenna. Good impedance and axial ratio characteristics have been obtained.

Key words : Circular polarization, Proximity method, Axial ratio, Cross slot.

I. INTRODUCTION

A circularly polarized antenna with a low profile, small size, and light weight is required in mobile satellite communications. Many types of micro strip antennas have been proposed and investigated .

Circularly polarized micro strip antennas are classified as single-fed type or dual-fed type, depending on the number of feed points necessary to generate the circularly polarized waves. The single-fed type has the advantage of not requiring an external polarizer such as a 90° hybrid coupler. The relation-ship between the optimum probe location and the frequency of the obtained circularly polarized wave has been clarified, and good experimental results have been reported. Recently, aperture-coupled feed methods have been attracting much attention because their geometries are suitable for monolithic integration with microwave or

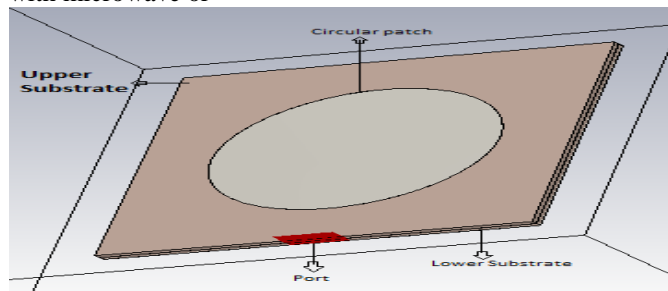
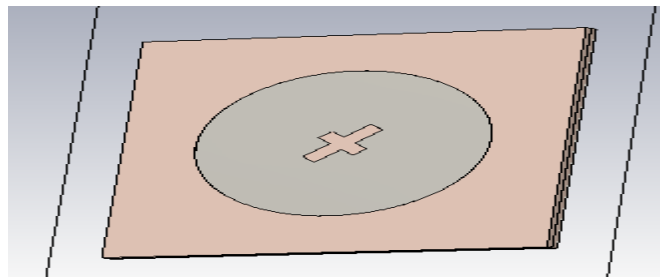
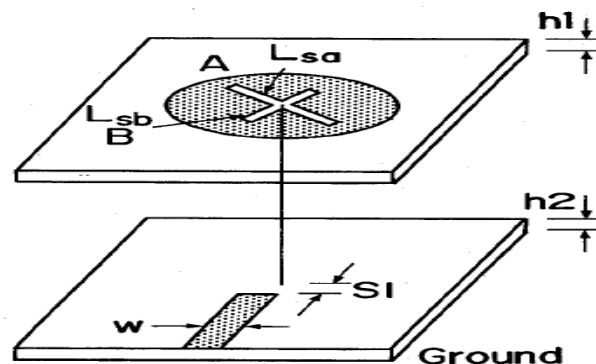


Fig.(a).Structure Without Slot



Fig(b).Structure With Slot

II. PROPOSED CONFIGURATION



Configuration of the proposed patch antenna.

Fig.1

mill wave devices. The feed position for a circularly polarized operation and the input

Impedance of several micro strip antennas fed by the slot coupled method have been investigated . However, with this type of micro strip antenna it is difficult to excite good circularly polarized waves.

Another suitable feed method is an electromagnetically coupled method which is also known as the proximity-coupled method. This type of antenna has several advantages over a directly fed patch antenna. By using a proximity-coupled method, an optimal feed point of a micro strip antenna has been proposed for linear polarization. Moreover, a circularly polarized rectangular micro strip antenna, fed by proximity coupled method using an offset micro strip line, was proposed by the author .

On the other hand, the element of a phased-array antenna must be arranged at almost about half wavelength to obtain wide-angle beam scanning. The resonant frequency of a single fed circularly polarized micro strip antenna with a thin diagonal a

patch antenna with a 90° hybrid. Therefore, it is difficult to arrange an antenna element at about half wavelength in the case of the above-patch antenna. The purpose of this paper is to propose a small-size circular patch antenna using a cross slot with unequal slot lengths. The proposed antenna can achieve circular polarization without the need for a 90° hybrid coupler. The measured results are presented to demonstrate the usefulness of the proposed antenna configuration. Good impedance and axial ratio characteristics are realized.

III. ANTENNA CONFIGURATION

The proposed antenna configuration is shown in Fig. 1. The circular patch with a cross slot and the micro strip line are formed by the substrates with a dielectric constant ϵ_r and thickness h_1 and h_2 , respectively. The radius of the circular patch is r . Slot A with length L_{sa} and slot B with length L_{sb} , cross orthogonally at the center of each slot, which is the center of the circular patch. The characteristic impedance of the micro strip line is 50Ω . SI is the distance between the end of the microstrip line and the center of the patch antenna.

IV. EXPERIMENTAL RESULTS

The resonant frequency of the linearly polarized circular patch with a slot can be controlled by changing the slot length. The resonant frequency decreases monotonically with increasing slot length. Therefore, resonant frequencies of orthogonal modes, as a result of the perturbation caused by a cross slot, as shown in Fig. 1, will decrease with increasing slot lengths L_{sa} and L_{sb} . Thus, the resonant frequency of the proposed patch antenna can be reduced. Consequently, the proposed antenna can be made small size and compact compared with a linearly polarized patch antenna with a single slot. The proposed antenna was designed and tested to verify circularly polarizing operation. The experimental models were made of **ROGERS RT5880** substrate with $\epsilon_r = 2.2$ and the thickness $h_1 = h_2 = 1.6 \text{ mm}$.

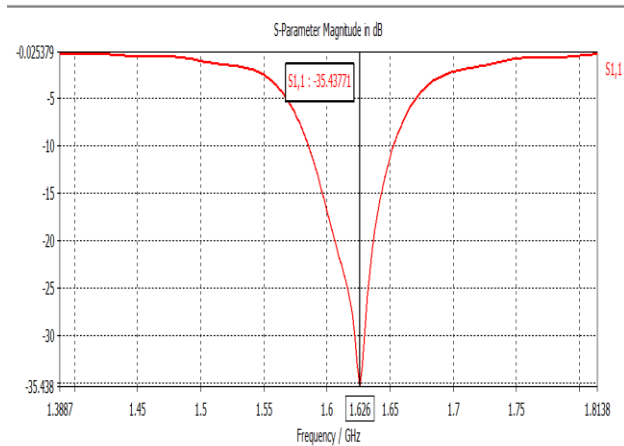


Fig.2(s-parameter)

The width of the micro strip line W was 4.5 mm. The radius of the circular patch without a cross slot was $r = 33.31 \text{ mm}$, and the resonant frequency was **1.646 GHz**. The patch antenna was designed by using the simple cavity method Fig. 2 shows the measured impedance and return loss for the $L_{sa} = 20.0 \text{ mm}$, L_{sb}

$= 12.0 \text{ mm}$, and $SI = 45.0 \text{ mm}$. Reference plane is the edge of the circular patch. Good impedance matching was obtained. The **bandwidth** VSWR less than 2 was **4.08%**. The resonant frequency of the circular patch antenna without a cross slot was 1.626 GHz. Therefore, the antenna radius can be reduced by about 2% using the cross slot configuration compared with that of the circular patch without a slot.

Fig. 4 shows the measured axial ratios as a parameter of the slot length L_{sb} . A 0.98-dB bore sight axial ratio was obtained at 1.626 GHz when $L_{sa} = 20.0 \text{ mm}$ and $L_{sb} = 12.0 \text{ mm}$. Fig.5 shows the measured gain was 7.4 dBi at the bore sight. To verify the possibility of achieving a reduction of the antenna size by using this proposed method, an antenna with $L_{sa} = 50.0 \text{ mm}$ and $L_{sb} = 36 \text{ mm}$, nearly equal to the diameter of the circular patch antenna, was tested. Fig.3 shows the radiation pattern in the 1.071 GHz . An axial ratio of about 3.0 dB was obtained in the $\pm 45^\circ$ range. Thus, the radius of the circular patch with a cross slot was reduced by about 22% compared with the radius of a circular patch without a cross slot. The gain was about 7.5 dB, which is greater than that the theoretical value of a probe-fed patch antenna without a cross slot.

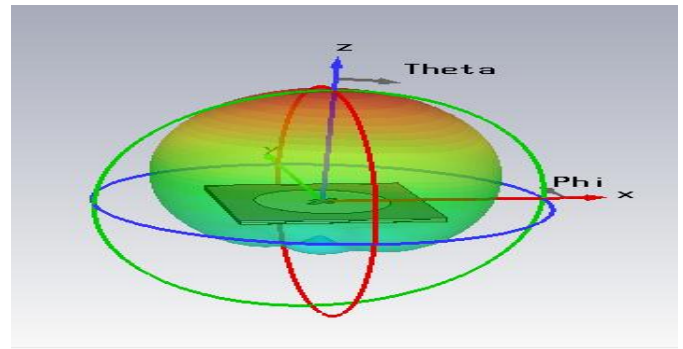


Fig.3(Radiation Pattern)

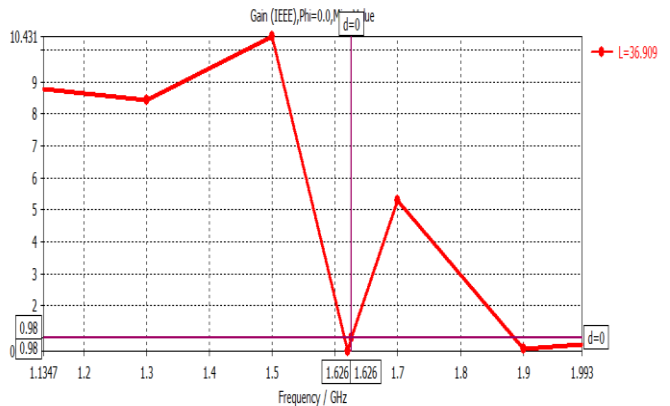


Fig.4(Axial Ratio)

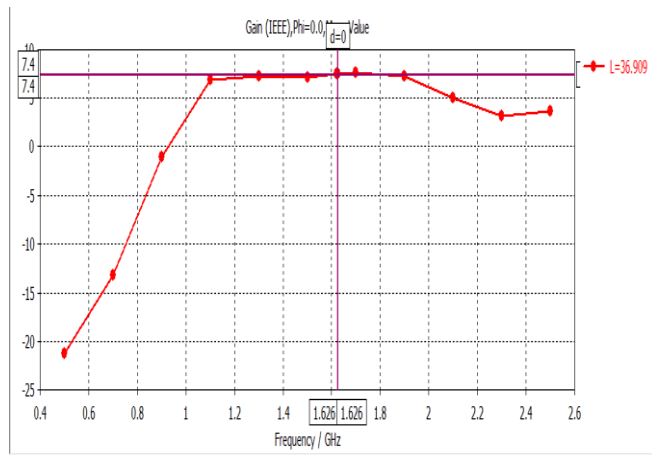


Fig.5(Gain)

V.TABLE

COMPARISON TABLE OF VARIOUS SIMULATED PARAMETERS.

Lsa(mm)	20	30	40	50
Lsb(mm)	12	20	28	36
f(GHz)	1.626	1.626	1.626	1.626
r(mm)	33.31	32.56	30.09	26.11
S11(dB)	-35.43	-28.8	-35	-30
Gain(dB)	7.4	7.3	7.39	7.5
AR(dB)	0.98	2.36	2.78	0.98
fa(GHz)	1.626	1.54	1.432	1.071
%BW	3.4	3.51	3.98	4.08

Where,

Lsa is length of slot A

Lsb is length of slot B

f is resonance frequency

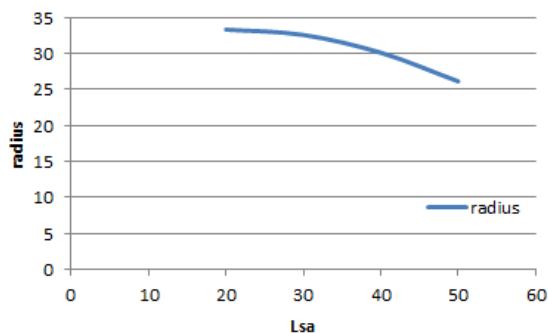
r is radius of circular patch

S11 is return loss

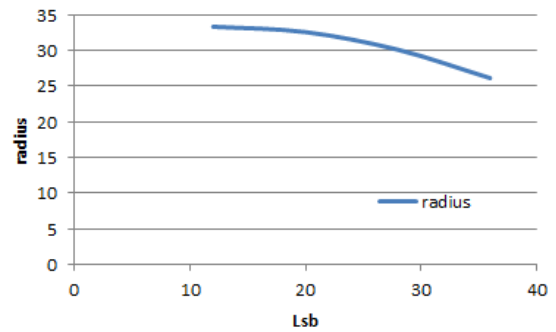
AR is axial ratio

fa is frequency after varying the slot length.

**Reduction Of Patch Radius With Increase In Slot Length
Radius Vs Slot Length(Lsa)**

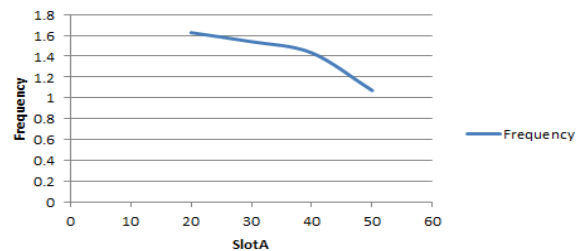


Radius Vs Slot Length(Lsb)

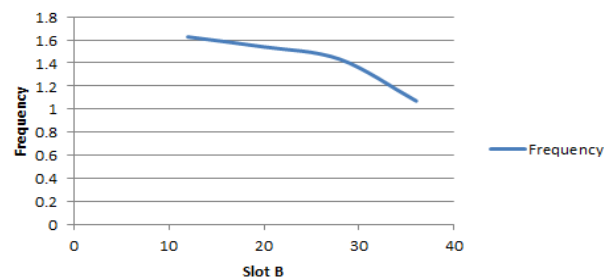


REDUCTION OF RESONANCE FREQUENCY WITH INCREASE IN SLOT LENGTH

Variation of Frequency with Slot A



Variation of frequency with Slot B



s-parameter magnitude in dB

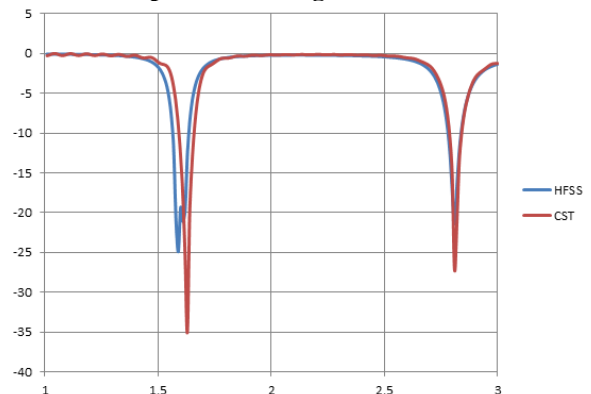


Fig.c

Fig c. shows the simulated CST and simulated HFSS matching frequency band of the proposed antenna for dB reflection coefficient from 1.56 GHz to 1.63 GHz with a bandwidth of

4.61% in simulation HFSS and the frequency band of 1.46 GHz to 1.52 GHz with a bandwidth of 4.08 % in simulation CST respectively. We can observe the good agreement between the HFSS and CST simulated radiation patterns.

VI. CONCLUSION

This paper describes the results of measurements of a new single-fed circularly polarized microstrip antenna. A small-size element antenna for circular polarization was realized by using a circular patch antenna with a cross slot having different arm lengths. The antenna radius was reduced by about 22% by using slot lengths which are nearly equal to the diameter of the circular patch antenna. The proposed antenna is suitable for application in the field of mobile satellite communications as a phased-array antenna using a multilayered feed network integrated with microwave devices.

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