# Investigations of an Aperture Coupled Circular Polarized Via Walls Backed Microstrip Patch Linear Array Antenna for Beam Steering Performance

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***Abstract*—A circularly polarized 1×16 linear array antenna with beam scan range of +/- 50° is investigated. The single antenna element is an aperture coupled microstrip patch with via walls backing and is fed using a sequentially rotated feedline. This radiating element helps in reduction of the inter-element spacing and overall array size miniaturization in addition to the acceptable axial ratio performance with beam scan for the array.**

***Keywords—Circular polarization, Aperture Coupling, Beam steering.***

## I. Introduction

Advanced communication systems demand miniaturized antenna technology together with directive and efficient antenna characteristics. Microstrip patch antennas are low profile, simple and low cost antennas with limited bandwidth and polarization purity. The circularly polarized antenna is preferred over linear polarized antenna as they reduce multipath defects and avoid polarization mismatch between transmitter and receiver. Wideband circular polarized aperture coupled microstrip patch antennas are reported in [1] and [2] with various feeding mechanism. Cavity backed element can improve the impedance bandwidth, isolation and miniaturize the structure [3]. In this paper, a linear array of the circularly polarized microstrip patch antenna backed with via walls showing beam steering performance is proposed. The full wave analysis is performed using Ansys HFSS v15. The single radiating element has been fabricated. Next we would fabricate the linear array and measure its radiation patterns before investigating the beam steering performance.

## II. Circular Polarized Antenna Element

The proposed single radiating element is an aperture coupled square microstrip patch with crossed slots and series feeding structure as shown in Fig. 1. The element is backed by via walls based cavity to suppress surface waves. The crossed slot retains symmetry to produce good polarization purity and achieves adequate coupling. When thick antenna substrates are used crossed slot provides wide bandwidth which also results in higher backlobe radiation [2]. Series feeding provides sequential rotation for the patch to provide a wideband axial ratio [2].

The top and bottom layer substrates are RT/duroid 5880 ($\varepsilon_r$=2.2, tan θ = 0.002) of height ($H_1$ and $H_3$) 30mil. The middle layer is foam ($\varepsilon_r$=1.07, tan θ = 0.002) of height ($H_2$) 2mm. The bottom side of top layer substrate has a square patch of length

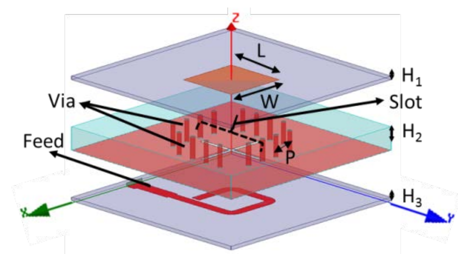



Fig. 1. Proposed aperture coupled microstrip patch antenna with via walls.

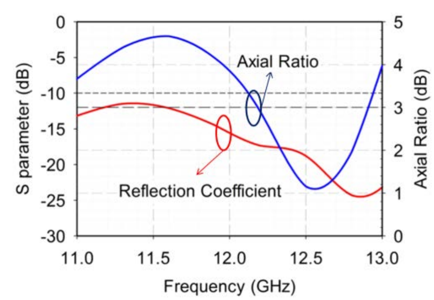



Fig. 2. Simulated Reflection Coefficient and Axial Ratio vs Frequency.

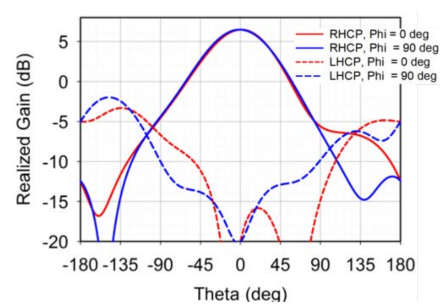



Fig. 3. Simulated 2D radiation pattern at 12.5GHz.

L=W=6.28mm to obtain good polarization purity. The foam has copper vias of diameter 0.4mm spaced at distance P=1.785mm. The cross slot has length and width of 7.7mm and 0.36mm, respectively. The common fractional bandwidth of 6.4% considering impedance bandwidth ($S_{11}$< -10 dB) and 3dB axial ratio (AR) bandwidth is from 12.18 GHz to 12.91GHz as shown in Fig.2. The realized gain of the antenna varies from 6dBic-6.7dBic over the desired bandwidth. The simulated radiation pattern at 12.5 GHz has a gain of 6.4dBic as shown in Fig.3.

## III. 1X16 LINEAR BEAM STEERING ANTENNA

The proposed antenna element is used to create a 1×16 linear array antenna as shown in Fig.4. The inter-element spacing is 0.42λ, where λ is free space wavelength at 12.5GHz which reduces the grating lobe enabling wide angle beam scanning. The reduced inter-element spacing is achieved by via walls based cavity which in turn preserves the 3dB AR bandwidth in the array configuration. The linear array is along the X axis (Phi = 0°) which enables beam steering along this axis.

The active S-parameter considers all the port excitations including coupling from other ports excited simultaneously. The active S- parameter of mid port# 8 is shown in Fig.5 (a). Other ports have similar characteristics but not included due to lack of space. The matching bandwidth is decreasing with an increase in scan angle. The 3dB AR bandwidth is reducing with scan angle. At ±50° beam angle position, the AR bandwidth is from 12.4 GHz to 12.75 GHz as shown in Fig.5 (b).

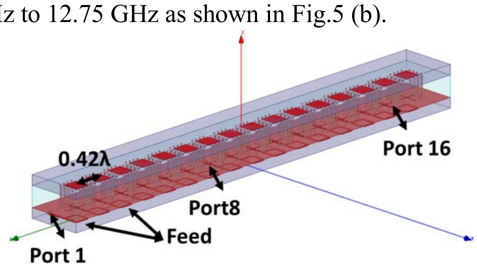
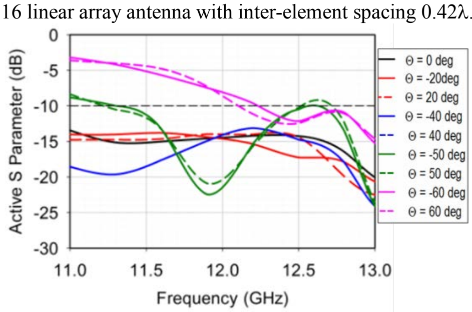
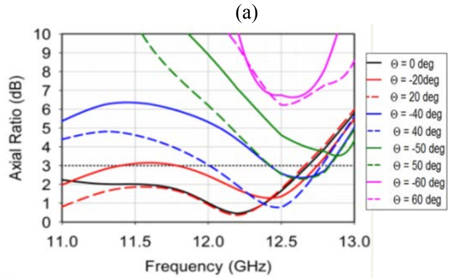



Fig. 4. 1×16 linear array antenna with inter-element spacing 0.42λ.




(a)




(b)

Fig. 5. 1×16 array (a) Active S parameter of Port # 8 and (b) AR, both with the scan angles.

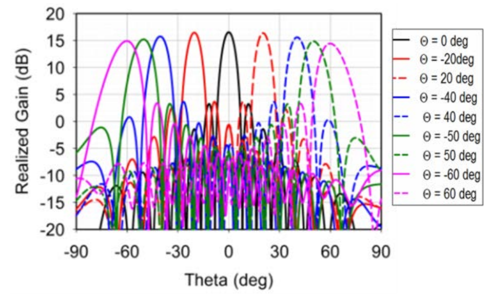



Fig. 6. 2D radiation pattern at 12.5GHz along Phi =0º plane with scan angles.

The 1×16 linear array provides a realized gain of 16.5dBic which is less compared to a case without via walls design. This reduction in gain is due to miniaturization in aperture area and losses in vias. The beam steering is shown in Fig.6, where the beam scan angle is between +/- 50° and the gain is varying from 16.5dBic to 15.1dBic.

## IV. CONCLUSIONS AND FUTURE STUDY

The via walls based cavity in the antenna elements enabled in reducing inter-element spacing to 0.42λ, which in turn enhanced beam scan angle without grating lobe but at the cost of reduced gain. The beam scan capability is until +/-60° but is limited by 3dB AR bandwidth. The single element has been fabricated as shown in Fig.7. The fabricated single element will be tested in addition to the linear array fabrication and experimental verification. Additional results will be presented during the symposium.

(a) (b)

Fig. 7. Fabricated antenna element (a) Top View and (b) Bottom View

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