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Design of High Gain Wideband Circularly Polarized 1B4T Stacked Microstrip Patch Antenna using Single Coaxial Feed

Pankaj Kumar[1], Ravi Jaiswal, Faseeh Ahmad[3]

[1]PG Student, Goel institute of Technology and Management Lucknow, Uttar Pradesh, India.
[2,3]Assistant Professor, Goel institute of Technology and Management Lucknow, Uttar Pradesh, India.

Abstract—*In this article design of high gain and wideband circularly polarized antenna is presented using stacked configuration of microstrip patch antenna providing air as gap with single coaxial feed. Basic radiating element of the proposed antenna consists of a thin driven patch at bottom suspended in air and four parasitic patch at top of stacked in same plane supported over thin FR4 dielectric substrate. Driven patch is fed through a coaxial feed whereas the parasitic patch is gap coupled to the lower patch. To get circular polarization, square slots are formed at the diagonal of each patch. This antenna is design and simulated on Ansys HFFS simulator. The Bandwidth for Axial ratio≤ 3dB,VSWR≤ 1.5 and Retrun loss≤15 dB, starts from 2.8 GHz and ends to 3.16 GHz providing 360 MHz band which is 12.53% of usable frequency with peak Gain of 9.5dB within 1dB variation. This band is resonating at 2.9GHz frequency which is suitable for S-band communication.*

Key words—Stacked patch, Square slot, Axial ratio, Gain, Wideband, Circular polarization, Gap coupling, Single feed.

1. INTRODUCTION

Circularly polarized antennas are used in various communication system such as in radar and satellite communications, global positioning systems, and wireless area local networks because it provides greater mobility and freedom in the orientation angle. In case of circular polarization, received signal strength is not deteriorated due to the relative rotational orientations of the transmitter and receiver within communication system. On the other hand, with linear polarization, complete signal loss can occur when the transmitter and receiver orientations are orthogonal to each other. Therefore, circular polarization is used to ensure reliability of the communication links. Circular polarization is achieved by generating two orthogonal modes either by using dual feeds or perturbations in the antenna structure. In case of dual orthogonal feeds, 90^{o} phase difference is maintained between the feed points to get circular polarization [1]-[3]. In case of single feed, antenna structure is perturbed through notches [10]-[12] or slits [13]-[15] to generate two orthogonal modes in the patch. The major advantage of single-feed, circularly polarized microstrip antennas is their simple structure, which does not require an external polarizer. Therefore, they can be realized more compactly and in simple way by using less board space than do dual-feed, circularly polarized microstrip antennas. However, the conventional single layer square patch with truncated edges exhibit narrow VSWR and axial ratio bandwidths [3]. In order to get higher gain and wider band width, parasitically coupled stacked patch antenna configurations are required [7]-[8]. Various single feed circularly polarized patch antenna configurations have been reported in the literature [4]-[15]. In this paper, a high gain and broadband microstrip patch antenna is reported using air gap stacked patch configuration. Basic radiating element of the proposed antenna consists of a thin driven patch at bottom suspended in air and four parasitic patch at top of stacked in same plane supported over thin FR4 dielectric substrate. Driven patch is fed through a coaxial feed whereas the parasitic patch is gap coupled to the lower patch. To get circular polarization, square slots are formed at the diagonal of each patch. The Axial ratio≤3dB, starts from 2.8GHz and ends to 3.16 GHz providing 360 MHz band which is 12.53% of usable frequency with peak Gain of 9.5dB within 1dB variation.

2. ANTENNA DESIGN

To get Circular Polarized, High Gain and Wideband, the square slotted 1B4T(One Bottom patch and Four patch at Top) stacked microstrip patch antenna by using coaxial feed is designed and simulated on Ansys HFSS. This antenna is a wideband antenna for S-band applications which resonate at 2.9 GHz frequency. In this design procedure of a microstrip patch antenna, of the desired resonant frequency, thickness of the substrate and dielectric constant of the substrate are known initially. In the designing of this kind of patch antenna, initially antenna is analyzed with a square patch. For better clarification 3D view and top view of proposed antenna is shown below. In the figure 2.1 3-D view of 1B4T stacked patch antenna are shown. This stacked antenna consist of one ground plane, one driven patch, FR4 substrate upon which four parasitic patches are placed and eight Teflon support. This antenna is feed with coaxial feed. In this structure four Teflon support is used to support driven patch because air substrate is used here and other four Teflon substrate is used to support top FR4 substrate on witch four parasitic patches are placed for this patch antenna design all the dimension are shown in Table I. In the figure 2.2 XY-plane view of top of stacked patch antenna is presented. All dimension of substrate and four parasitic patches is as follows: FR4 substrate is of length Ls and width Ws, all four parasitic patches of length Lt and width of Wt and each slot on parasitic patch is of dimension of length ‘u’ and width ‘v’. In this figure there is four cylindrical Teflon support of radius Rs=1.5mm.

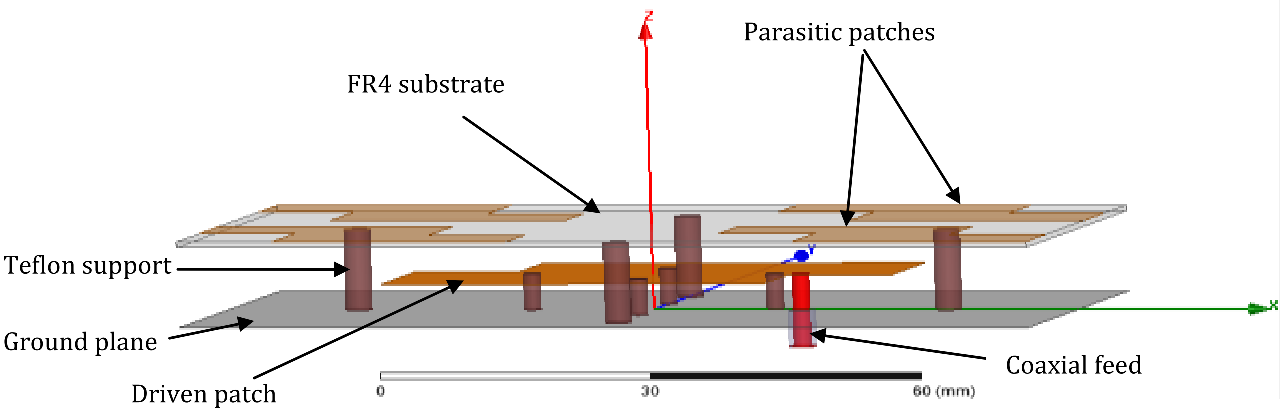


Figure 2.1 3-D view of 1B4T stacked patch antenna

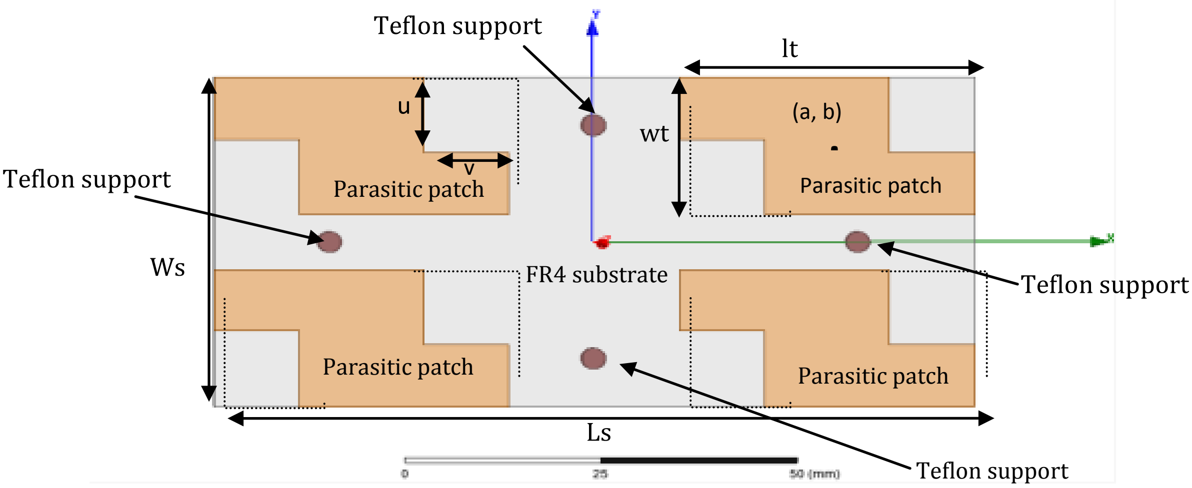


Figure 2.2 Top patches view

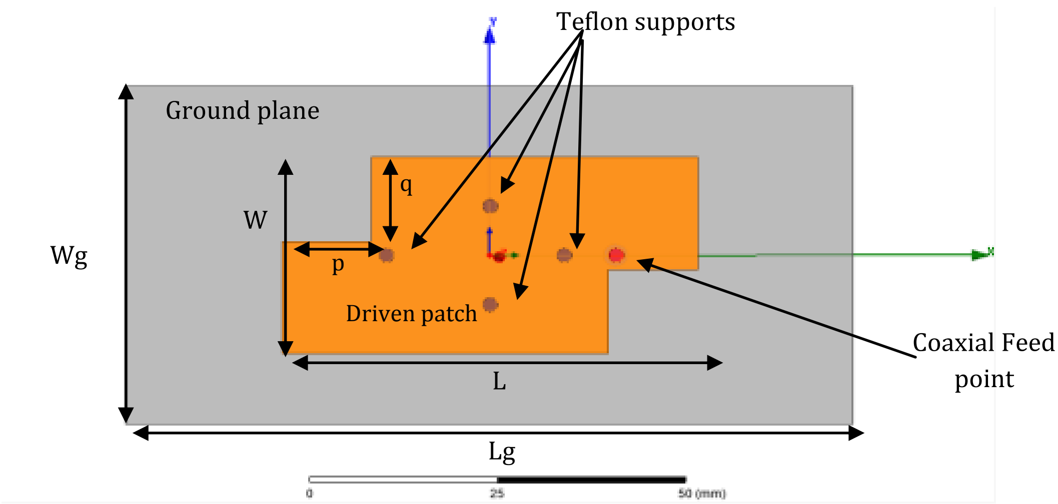


Figure 2.3 Driven patch (Bottom) view

In the figure 2.3XY-plane view of driven patch above ground plane is presented. All the dimension of ground plane and driven patch as follows: Ground plane is having of length Lg and width Wg, driven patch is of length L and width W and each four slot is of dimension of length 'p' and width 'q'. In this figure also there is four cylindrical Teflon support of radius Rd=1mm. Feed point location is given as (fx, fy, fz).

Table of Parameter I

Parameters name	**Variable**	**Value(in mm)**
Ground plane length	Lg	98
Ground plane width	Wg	48
Driven patch length	L	56
Driven patch width	W	28
Driven patch height	h	5
Driven patch slot length	p	12
Driven patch slot length	q	12
Parasitic patch length	Lt	38
Parasitic patch width	Wt	20
Parasitic patch height	ht	12
Parasitic patch slot length	u	11
Parasitic patch slot width	v	11
FR4 substrate length	Ls	98
FR4 substrate width	Ws	48
FR4 substrate height	hs	11.2
FR4 substrate thickness	Δ	0.8
Feed point location	(fx, fy, fz)	(17,0,0)
Offset point location	(a, b)	(30,14)

3. SIMULATED RESULTS:

Return loss

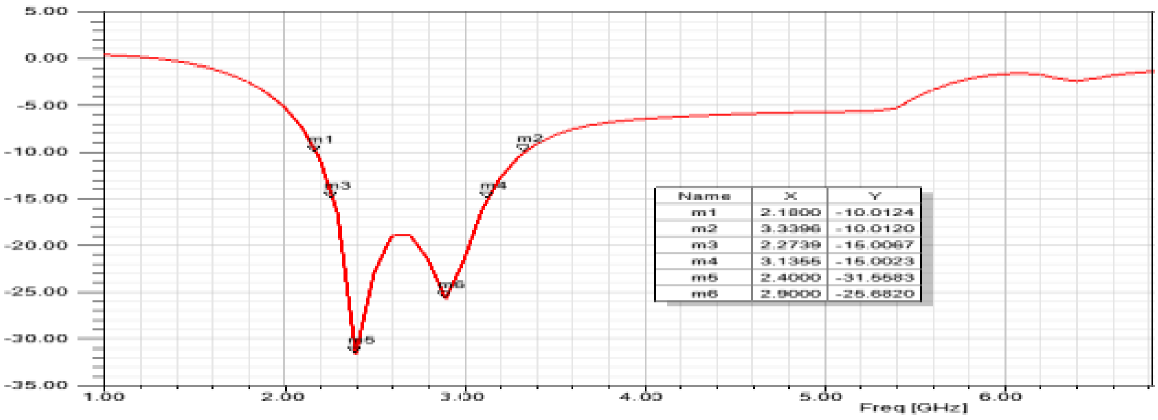


Figure 3.1

Vswr

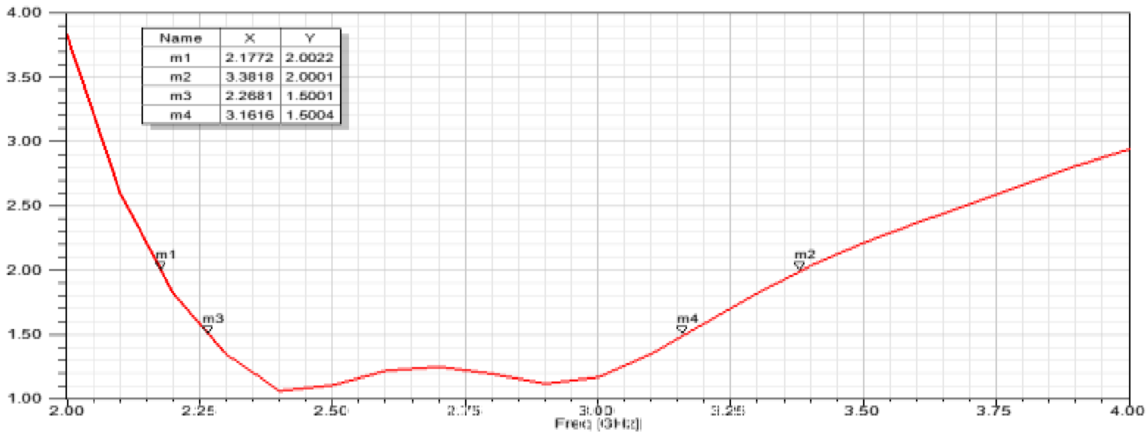


Figure 3.2

Axial ratio

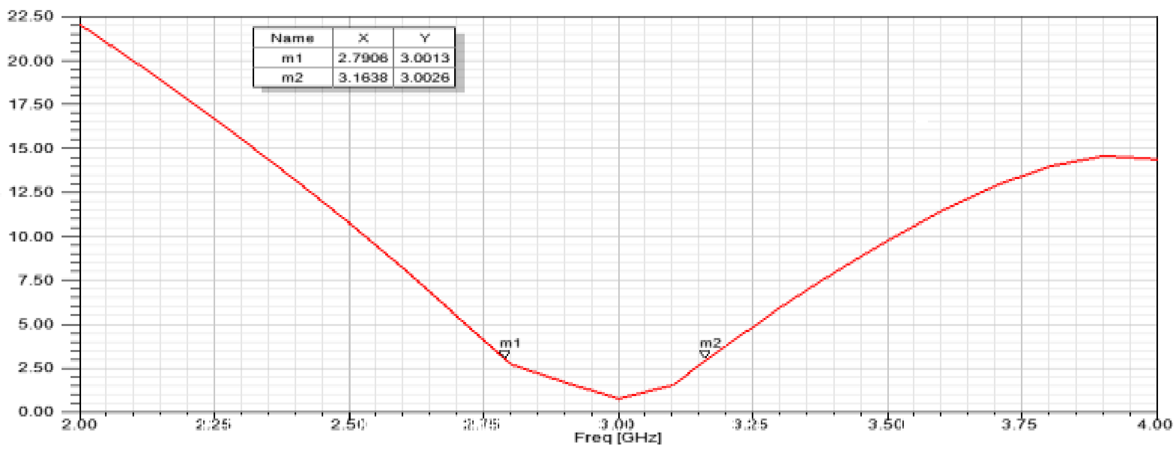


Figure 3.3

Gain versus Frequency

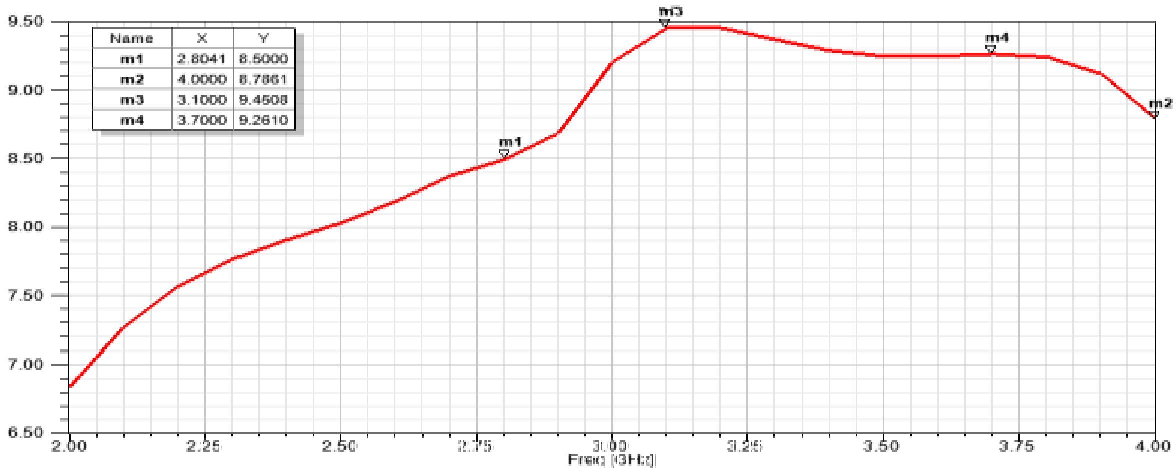
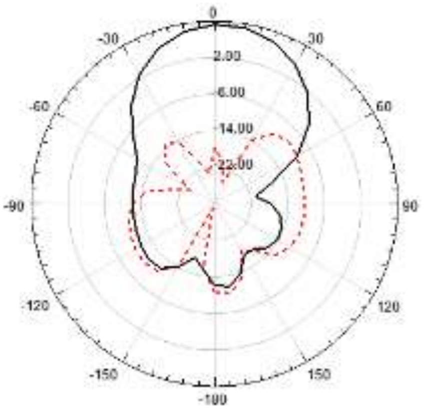


Figure 3.4

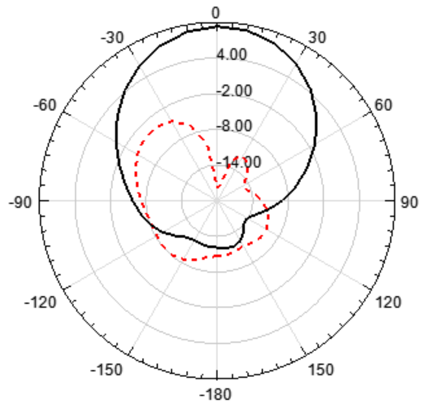
Radiation pattern

LHCP
RHCP

E-Plane pattren

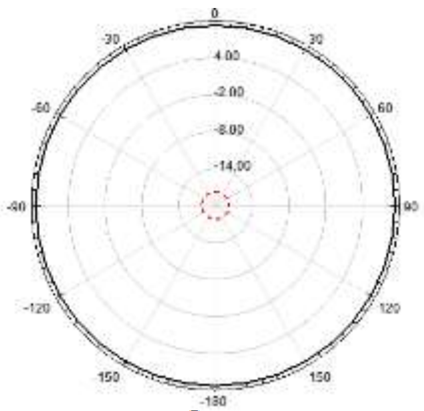


(a) Ø=0°

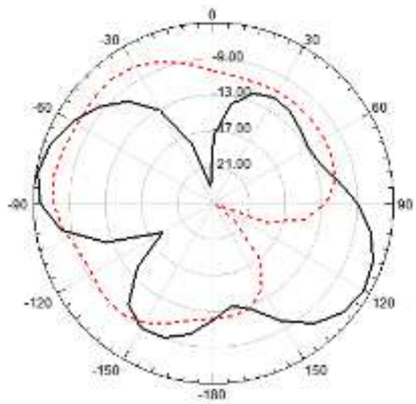


(b) Ø=90°

H-Plane pattren



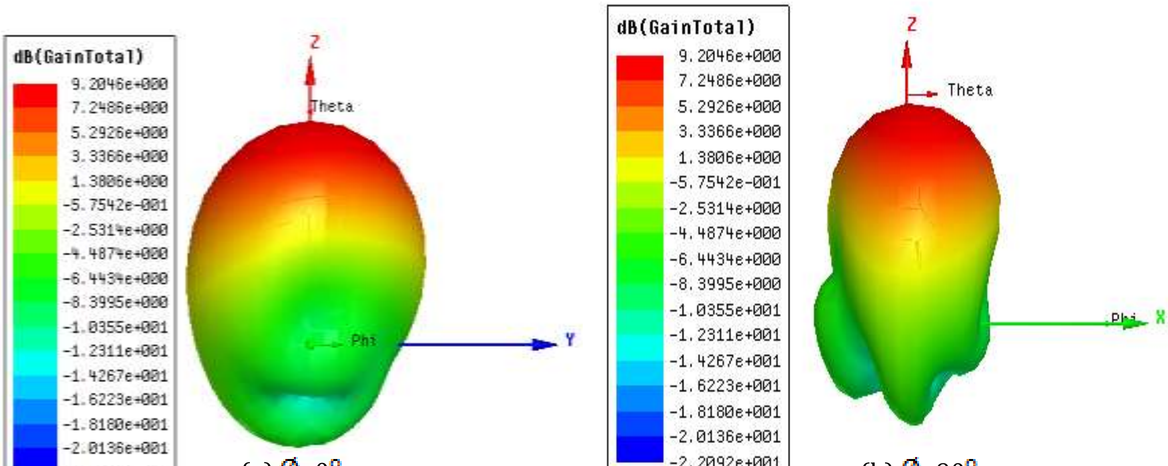
(c) θ=0°



(d) θ=90°

Figure 3.5

3-D polar plot



(a) Ø=0° (b) Ø=90°

Figure 3.6

3.1 RESULT DISCUSSION:

From the figure 3.1 we can see that the 10 dB bandwidth is from 2.18 GHz to 3.34 GHz which is 42% and 15 dB bandwidth is from 2.27 GHz to 3.15 GHz which is 31.85% with two resonant frequency of 2.4 GHz and 2.90 GHz. VSWR plot is given in the Figure 3.2 VSWR ≤2 bandwidth exits from 2.17 GHz to 3.38 GHz which gives 59% and VSWR≤ 1.5 bandwidth start from 2.26 GHz and end to 3.16 GHz which gives 33% bandwidth. The 3dB Axial ratio bandwidth in figure 3.3 start from 2.79 GHz and ends to 3.16 GHz which gives 12.53% bandwidth. The axial ratio exhibits property of circular polarized wave, for normal application it must be less than and equal to 3dB. In the figure 3.4, Gain bandwidth above 8.5dB start from 2.8 GHz and go beyond 4 GHz with peak gain of 9.45 dB at 3.1 GHz. In the figure 3.5 both E-plane and H-plane radiation pattern results are plotted. In this figure we can see that antenna is radiating in broadside direction and also in single direction. It gives conclusion that our antenna is broadside and unidirectional. In the Figure 3.6 the 3-D polar plot of antenna radiation power is plotted. 3-D polar plot of antenna radiation exhibits how much strength of power antenna is transmitting in the space. The peak strength of radiation power is 9.28 dB in forward direction and -8.33 dB in backward direction at 2.9 GHz. Hence the FBR(Front to Back Ratio) of antenna is 17.61 dB which gives unidirectional property of antenna.

4. CONCLUSION

A broadband and high gain circularly polarized microstrip array antenna is designed for applications in S-band communication using single feed. The major advantage of single feed, circularly polarized microstrip antennas is their simple structure, which does not require an external polarizer. Therefore, they can be realized more compactly and simple way by using less board space than do dual-feed, circularly polarized microstrip antennas.

The antenna exhibited excellent performance in terms of Return loss, VSWR, Axial ratio, Gain and Bandwidth. This antenna can be serve as best alternatives where multiple channels are need to be accommodates and hence it fulfills necessary of using two are more antennas for multiple channel applications. In order to achieve more polarization purity sequentially rotated elements and feed network can be designed. In order to increase the gain and bandwidth further, antenna can be designed over RT-Duriod 5870 substrates with a significant compromise on the size of antenna due to high dielectric constant of RT-Duriod 5870 substrates.

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