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Parametric Analysis of Planar Circular Monopole Antenna for UWB Communication Systems

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ABSTRACT: A simple design of low cost planar circular monopole antenna for ultra-wideband (UWB) communication system applications is presented. The proposed antenna consists of a planar circular radiating patch fed by a simple 50Ω microstripline feed. The antenna is etched on a substrate area of 50 × 3.8 mm^2.By properly adjusting the physical parameters of the antenna a wide impedance bandwidth can be achieved from 2 to 12.63 GHz which is 145%. The parametric analysis based on obtained results of the proposed antenna is discussed and presented.

KEYWORDS: Planar circular monopole antenna, 50Ω microstripline feed, UWB.

I.INTRODUCTION

In present days the different wireless communication systems are very emerging for many applications. The main reason is that the Federal Communications Commission (FCC) released the very wide frequency spectrum (3.1 - 10.6 GHz) for various commercial terrestrial applications in February 2002 [1]. The UWB communication technology become a highly important in both academia and industries due to offering many features such as availability of enormous bandwidth, high data transmission, very low power consumption, low complexity and low cost [2]. In recent years, many broadband monopole antenna geometries such as rectangular, square, elliptical, triangular, circular, semi-circular, pentagonal etc. have been studied and reported for UWB applications [3-8]. These monopole antenna structures yield a very wide impedance bandwidth and easy to fabricate. However, these monopole antennas are generally not in planar structure because the radiating elements are constructed on air dielectric with an additional perpendicular ground plane. Hence, these types of monopole configurations are difficult to use for MMIC and other integration technology. To overcome this problem in present and for future communication technology the planar monopole antennas are best candidate for UWB wireless communications. Among various UWB antennas the circular monopole antennas are attractive due to simple in structure, UWB characteristics, dipole-like radiation patterns and low cost constraints.

In this paper, a simple low cost planar circular monopole antenna for UWB communication is presented. The proposed antenna is fed by using 50Ω microstripline feed and the parametric analysis is marginally extended based on previous work [9-10]. The parameters such as variation of height of partial conducting ground plane and width of partial conducting ground plane are studied to achieve the wide impedance bandwidth. Also by varying the length of the microstripline feed, the change of impedance bandwidth is observed. Moreover in this paper a low cost commercially available modified glass epoxy substrate material is used for antenna design.

II.ANTENNA DESIGN

The top and side view configuration of the proposed antenna is as shown in Fig. 1. The antenna consists of a circular radiating patch of radius *a* = 10.7 mm is fed by a simple 50Ω microstripline feed on the substrate and a partial ground

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plane is composed at the bottom side of the substrate. The antenna is designed on the low-cost modified glass epoxy substrate material with relative permittivity of 4.2, thickness of 1.6 mm and a tangential loss $(\tan\sigma)$ of 0.02. The antenna occupies on the substrate material with an area of $L \times W = 50 \times 3.8$ mm^2. The antenna has a 50Ω microstripline feed of width W_f = 3.17 mm and length L_f = 20.95 mm. On the bottom side of the substrate a partial conducting ground plane of length L_g= 20.45 mm and d (0.5 mm) is the distance between feed point of the circular radiating patch and the bottom ground plane is used. At the tip of microstripline feed a microwave source is assigned.

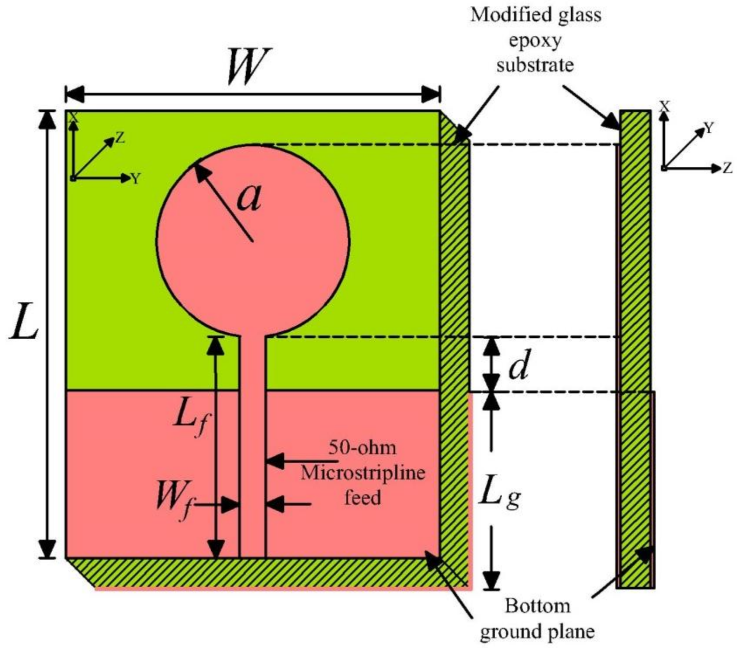

Fig. 1 Top and side view geometry of proposed circular monopole antenna

III.RESULTS AND DISCUSSION

The present parametric analysis is influenced by studying the initial design presented in [3], [4] which is a design of a circular disc monopole antenna fed by a 50Ω microstripline feed printed on the top surface and a conducting partial ground plane printed on the bottom side of the FR4 substrate of thickness 1.5 mm. The antenna provides a wide impedance bandwidth from 2.69 to 10.16 GHz and the simulations were performed using the commercial electromagnetic simulation software Ansoft HFSS package [11]. It is seen from the various simulation antenna prototypes that, we may study the effect of monopole antenna by varying the parameters such as d,W, L_g, $L_f$whicharequite effective for improving the antenna performance.

Figure 2 illustrates the variation of return loss versus frequency curves of proposed antenna.First by varying the feed gap distances d (d = 0 mm, 0.5 and 0.1 mm) between the feed point of the radiating patch and the ground plane it is seen that, if width of the ground plane Wwhich is equal to width of the substrate is kept fixed at 38 mm the antenna gives highest impedance bandwidth of 144% when d= 0.5 mm. This indicates that d is the parameter to change the impedance bandwidth of antenna.

Figure 3 shows the variation of return loss versus frequency curves with optimal designs for different widths W of bottom ground plane when feed gap d is fixed at 0.5 mm. From this figure it is evident that, the antenna gives highest impedance bandwidth of 149% when W= 38 mm. Hence W is one of the parameter to change the impedance bandwidth of antenna.
The other parameter of the proposed antenna i.e. length of the microstripline feed L_f is also effective in enhancing of the impedance bandwidth. Figure 4 shows the variation of return loss versus frequency curves with optimal designs of different length of microstripline feed L_f when W is fixed at 38 mm. It is seen from Fig. 4 that, by varying the length of

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the microstripline feed i.e. L_f the variation in impedance bandwidths are observed. The highest impedance bandwidth of 144% is found when L_f = 20.95 mm.

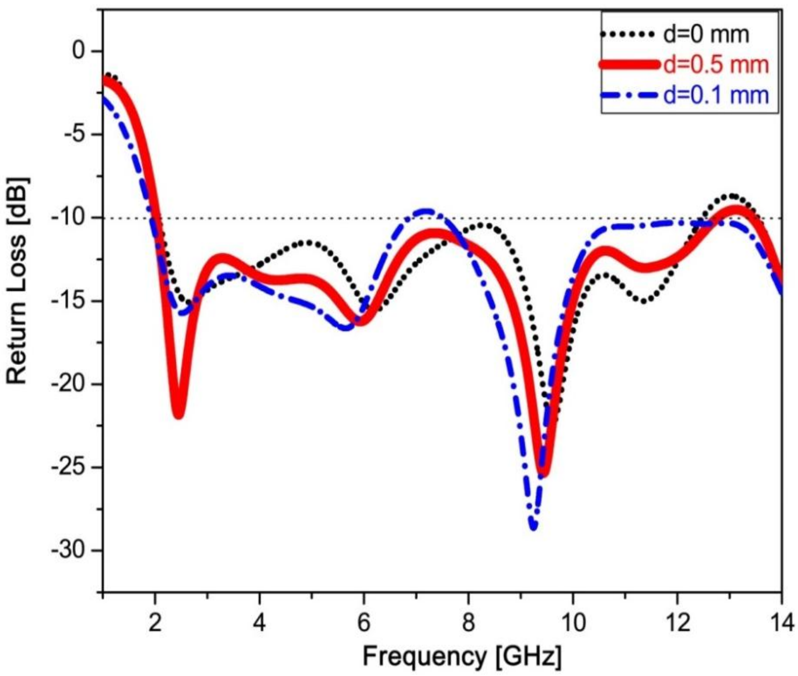

Fig. 2 Variation of return loss versus frequency curve for different feed gaps *d* when *W* = 38 mm

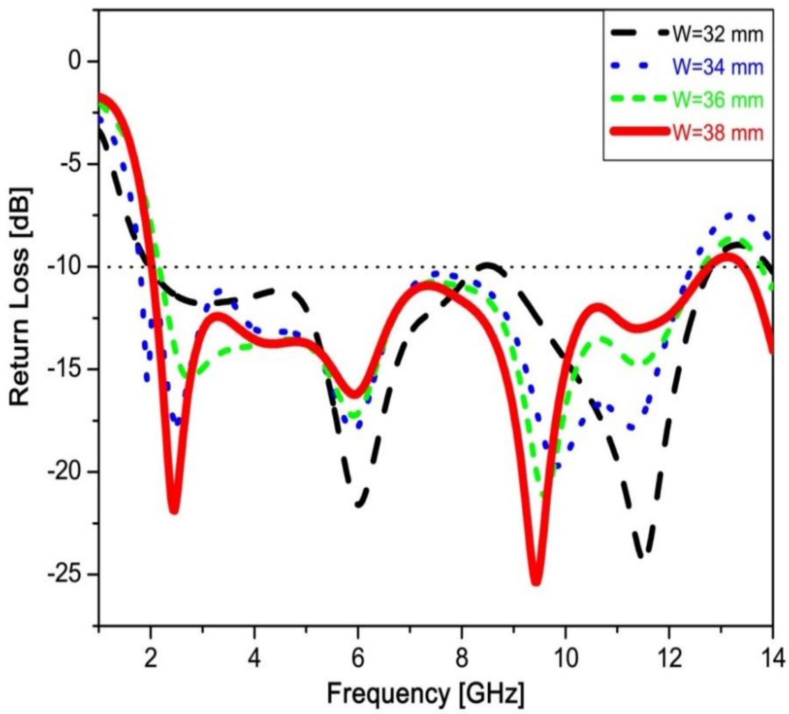

Fig. 3 Variation of return loss versus frequency curve for different width *W*of the ground plane when *d*=0.5 mm

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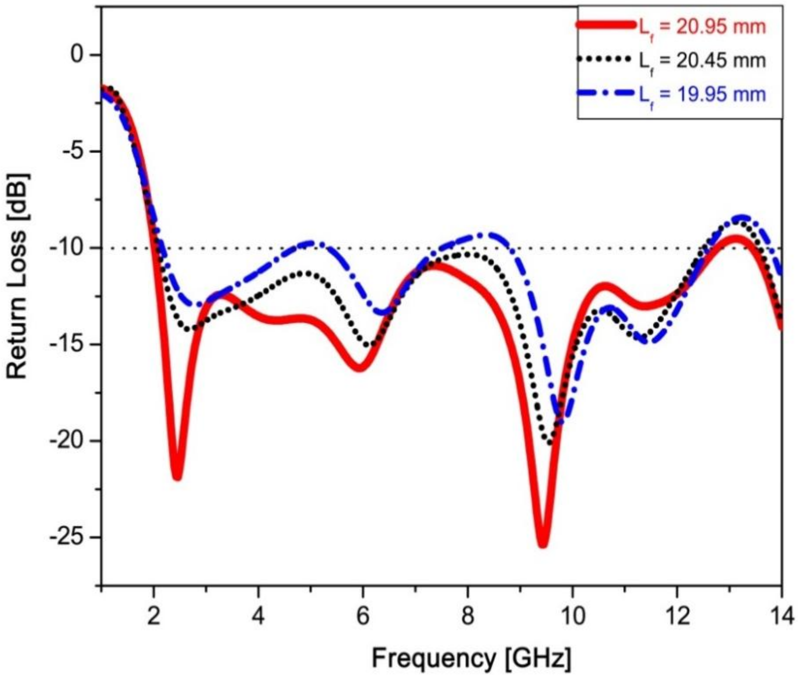

Fig. 4 Variation of return loss versus frequency curve for different length of the microstripline feed L_f when W= 38 mm.

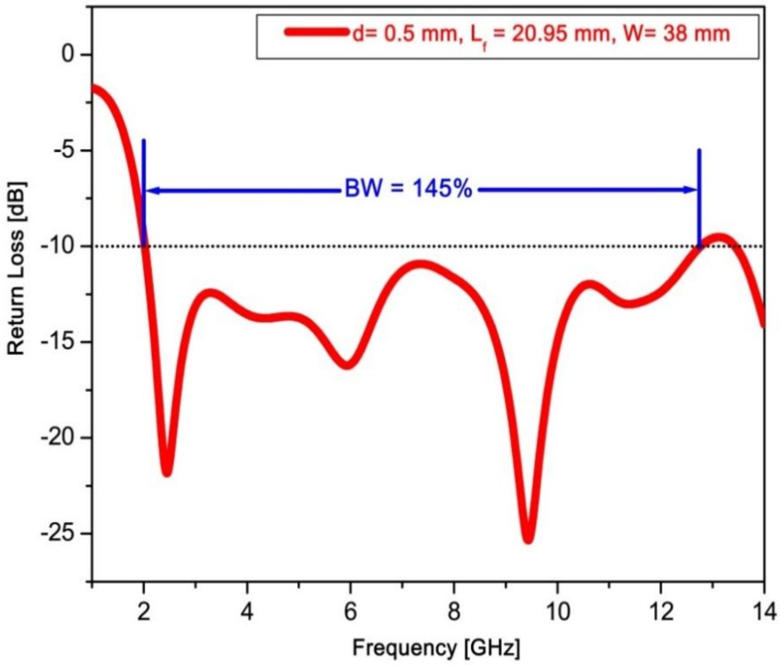

Fig. 5 Variation of return loss versus frequency curve of proposed antenna with optimal design parameters d= 0.5 mm, W= 38 mm and L_f = 20.95 mm

Figure 5 shows the variation of return loss versus frequency of proposed antenna with optimal design parameters i.e. h = 0.5 mm, L_f = 20.95 mm and W = 38 mm. From this figure it is clear that, the antenna gives a highest impedance bandwidth of 145%. A return loss curve less than -10 dB lies from 2 to 12.63 GHz. This impedance bandwidth is 29%

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more than the impedance bandwidth of monopole antenna found in [3], [4]. The optimal dimensions of various parameters of circular monopole antenna are shown in Table-I.

Table -I:The optimal dimensions of variousparameters of proposed antenna

Parameter	*W*	*L*	*a*	W_f	L_f	L_g	*d*
Dimension (mm)	38	50	10.7	3.17	20.95	20.45	0.5

The typical radiation patterns of the proposed antenna measured at 2.44 GHz, 5.94 GHz, 9.45 GHz and 11.40 GHz are shown in Fig. 6(a)-(d). From these figures it is clear that, the proposed antenna gives nearly omnidirectional radiation characteristics in its operating band.

Figure 7(a)-(d) shows the distribution of the current density on the surface of the proposed antenna at 2.46, 5.94, 9.45 and 11.40 GHz for the optimal design parameters *d* = 0.5 mm and *W* = 38 mm and L_f= 20.95 mm. From these Figures, it is clear that, the current is mainly distributing at the edge feed point of the circular radiating patch. From Fig. 7(a), it is seen that, the current is uniformly distributing towards the edge of the radiating patch and that gives the fundamental resonant frequency which is dependent to the radius of the circular radiating patch and surface current density is large. While in Figures 7(b), 7(c) and 7(d) the weak surface current distribution is observed along at the edge of the radiating patch.

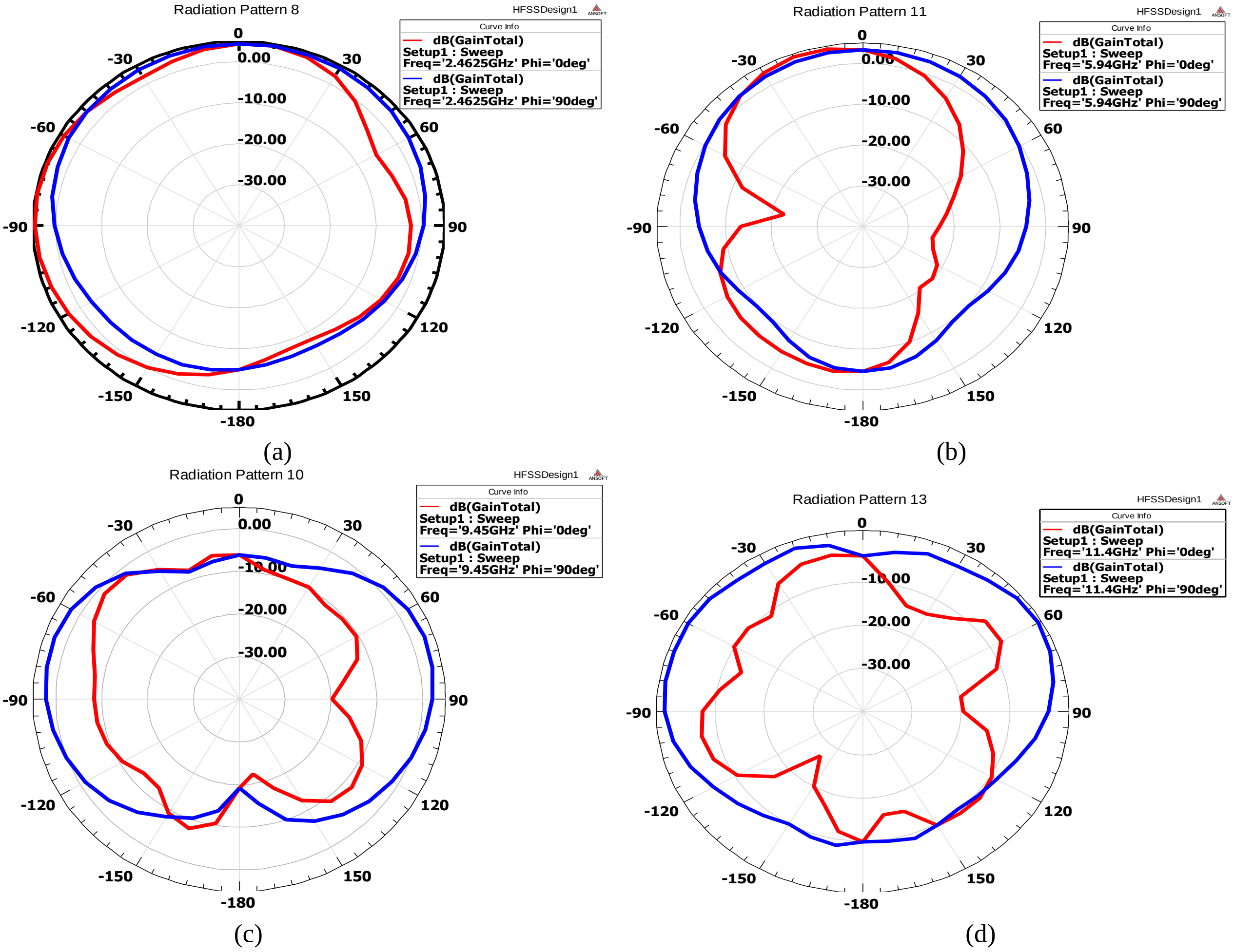

Fig. 6 Typical radiation pattern of the proposed antenna measured at (a) 2.46 GHz, (b) 5.94 GHz, (c) 9.45 (d) 11.40 GHz with optimal design parameters *d*= 0.5 mm, *W*= 38 mm and L_f= 20.95 mm

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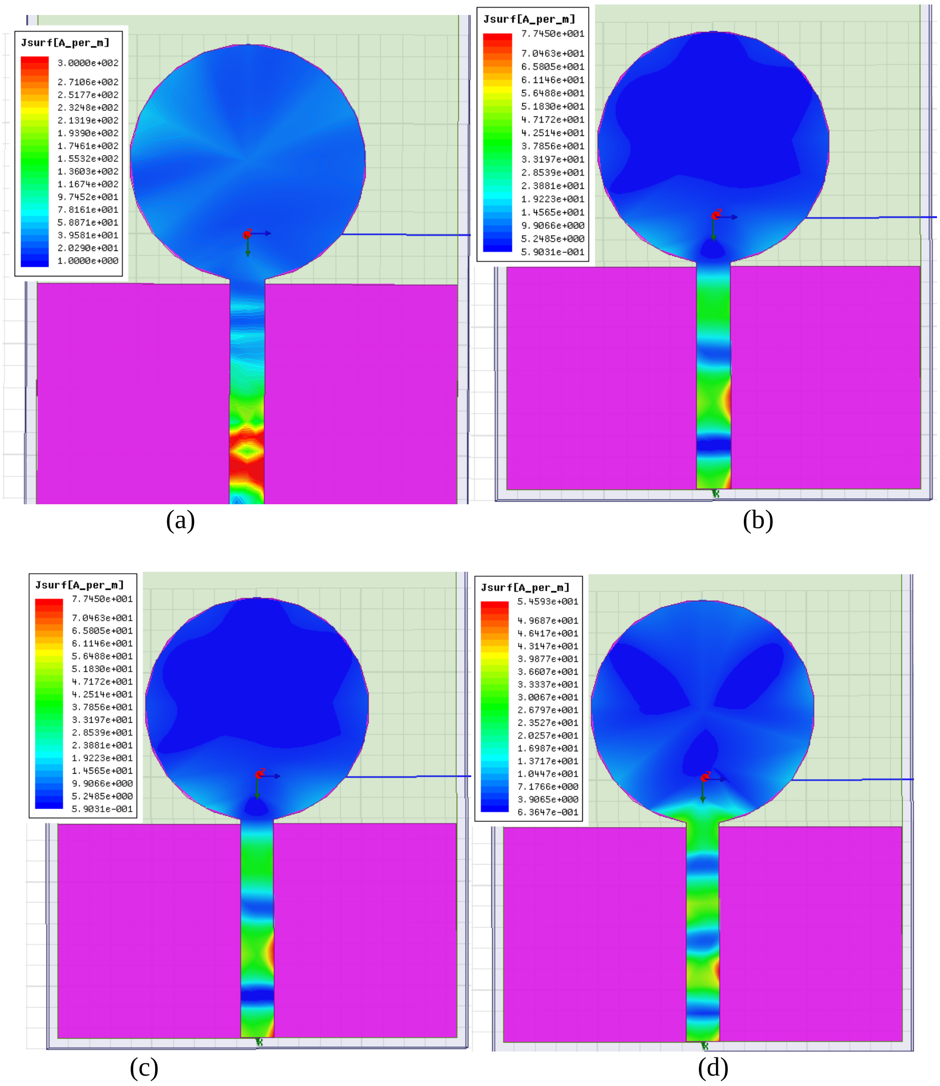

Fig. 7 Distribution of surface current density of proposed antenna at (a) 2.46 GHz, (b) 5.94 GHz, (c) 9.45 GHz and (d) 11.40 GHz with optimal design parameters d= 0.5 mm, W= 38 mm and L_f= 20.95 mm

IV.CONCLUSION

In this paper a design of simple circular monopole antenna fed by microstripline is presented for ultra-wideband communication applications. The proposed antenna gives the -10 dB return loss impedance bandwidth covering the frequency ranges from 2 to 12.63 GHz. This impedance bandwidth is 145% which is 29% more that found in earlier work. The parametric studies of the antenna were also conducted and investigated the change in the performance of the antenna by varying the various dimensions of the parameters. It is observed that, the entire change in impedance bandwidth performance is very much dependent on the physical parameters such as edge feed gap d, width of the ground plane W and length of the microstripline L_f.The typical radiation patters shows omni-directional in nature at its operating bands. The proposed antenna is planar, simple and uses low cost substrate material.

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BIOGRAPHY

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