Microstrip-fed broadband circularly Polarized monopole antenna

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Abstract - *A microstrip-fed broadband circularly polarized (CP) monopole antenna studied. Impedance bandwidth and large axial ratio bandwidth (AR-BW) obtained at a time. This antenna used a monopole architecture, except for it ground plane and asymmetric feeding.The asymmetric-feeding used to provide an orthogonal component different from its linearly polarized wave. Also, by adding a rectangular slit and a stub on the ground plane of antenna produce CP wave and to obtain an impedance bandwidth. As per the simulated results, the impedance bandwidth was 6.72 GHz with a return loss of a 10 dB, which covered a range of 2.09– 8.20 GHz. The AR-BW was 1.37 GHz for a 3 dB AR, which covered a range of 3.52–4.89 GHz.*

Key Words: **Microstrip, Stub, Slit, Monopole, Asymmetric.**

INTRODUCTION

Recent applications of circularly polarized (CP) waves have attracted much attention due to their significance in resisting inclement weather as compared to linearly polarized (LP) waves. They employed in modern communication systems that are sensitive to climatic variations, such as satellite systems and mobile communication systems radar tracking, navigation, [1]. The hazard caused by misalignment can be ignored to simplify antenna mounting as well as to improve reception efficiency. Exciting a CP wave requires two conditions: first, the amplitudes of two near degenerate equal orthogonal E vectors; second, the phase difference (PD) between the two orthogonal E vectors must be approximately 90°. Right-hand circular polarization (RHCP) or left-hand circular polarization (LHCP) can define by a 90° phase lead or lag. Traditionally, a polariser has required for exciting a quadrature phase contribution to producing CP. Some approaches have employed couplers, dividers or phase shifters to provide a 908 PD [2]. These mechanisms have referred to as the so-called dual-feed technique. On the other hand, some researchers established a cavity model to estimate the central frequency of CP and the polarized sense based on the physical dimensions and feeding positions of the antenna [3–5]. These configurations enabled CP capability to be realized using a single-feed method, which simplified the feeding. In addition to microstrip antennas, many types of antennas can efficiently achieve CP, such as slotted antennas [6], and arrays [8]helical antennas [7]. In last years, numerous studies designed CP asymmetric antennas.Ojiro in 1998, used a monopole feed and a symmetrical loop to generate a traveling wave current and realize CP [9]. A coplanar waveguide (CPW)- antenna utilized to produce a circular polarization mode between the sleeve and monopole antenna [10].

Paper states an asymmetric microstrip-fed monopole antenna to obtain a wide impedance bandwidth and broad axial ratio bandwidth. This antenna contains a rectangular radiator with asymmetric feed line and a ground plane with an embedded slit and stub. Asymmetric feeding achieves an impedance bandwidth and excites an elliptically polarized (EP) wave. By changing the shape of the plane, antenna produces a broad impedance bandwidth and wideband CP simultaneously. The work presents parametric studies of the antenna geometry, and the measured results show that this antenna generates a wide impedance bandwidth of 102.5% at a center frequency of 5.43 GHz and a wide CP radiation wave of 32.6% on a center frequency of 3.8 GHz.

1 THE OPERATION OF CIRCULAR POLARIZATION

Feeding structures typically classify into two categories, central feeding and asymmetric feeding, which can cause different surface current distributions on an antenna. Fig. 1a shows the surface current distribution for symmetric feeding, which can divide by horizontal and vertical currents. The orientation of the horizontal current excites two components that are 180° out of phase. Therefore the radiation in the far field in the horizontal direction is weak. Thus, it is tough for a conventional monopole antenna to excite CP. Asymmetric feeding produces two currents, which consist of horizontal and vertical currents, as see in Fig. 1b. Their PD and amplitudes do not give CP requirement; so, the asymmetric feeding technique can generate an EP wave. CP achieved by two orthogonal E vectors with equal amplitudes and a 90° PD. It defined as

$$E = E_{Hor} + e^{j\delta} E_{Ver}$$

Where E is the instantaneous electric field vector, EHor and Ever, respectively, denote the electric field vectors in the H plane and V planes, and δ is the PD. If the amplitudes of EHor and Ever are equal and δ =±90°, the polarized wave is RHCP or LHCP [7]. Also, the value of the axial ratio (AR) can be used to represent the characteristic of the polarization. The AR defined by the RHCP or LHCP , and it expressed as

$$AR = 20\log \left|\frac{\rho+1}{\rho-1}\right|$$

Where

$$\rho = \left|\frac{Erhcp}{Elhcp}\right|$$

There are three types of polarized waves: LP, EP, and CP. For a perfect CP wave, the AR value is 0 dB; for a perfect LP wave, the AR value is infinite. EP is live within CP and LP. A CP wave with AR = 0 dB is ideal; CP is typically defined based on an AR value of less than 3 dB.

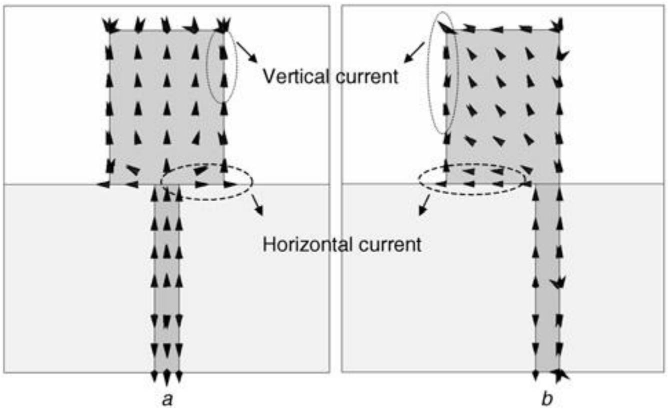

Fig -1: Current distributions at 3 GHz

a. Central feeding b. Asymmetrical feeding

but it excites EP. Equal amplitudes and a 90° PD, a slit was embedded on the ground plane. Using this approach, the amplitudes of EHor and Ever were almost equal, and the phase of EHor led Ever with a 90° PD, which produces an LHCP wave. The amplitude difference and Microstrip-fed broadband circularly Polarized monopole antenna.

2 ANALYSIS OF ANTENNA DESIGN

Fig. 2 shows the simulated current distribution. The two orthogonal vectors EHor and Ever have amplitudes, and PD-varied to excite the CP. Furthermore, adding a stub on the ground plane further increased the impedance bandwidth, while retaining CP performance. Fig. 3 illustrates the configuration of the proposed monopole antenna. The proposed antenna etched on an FR4 substrate with a relative permittivity εr= 4.4, loss tangent tan δ=0.024 and thickness H = 1.6 mm. The top view in Fig. 3a shows that rectangular radiator of width W2 and length L2 connected by an asymmetric feed line of width W1 and length L1. As in the bottom view in Fig. 3b, L1 × W ground plane etched on the bottom side of this antenna. An S1 × S2 rectangular slit embedded on the ground plane, and a D1 × D2 stub embedded on the ground plane. The size of an antenna (L × W × H) of the proposed antenna have dimensions approximately 45 ×40 × 1.6 mm3. Fig. 4 shows a flowchart of the design process used for the proposed CP monopole antenna.

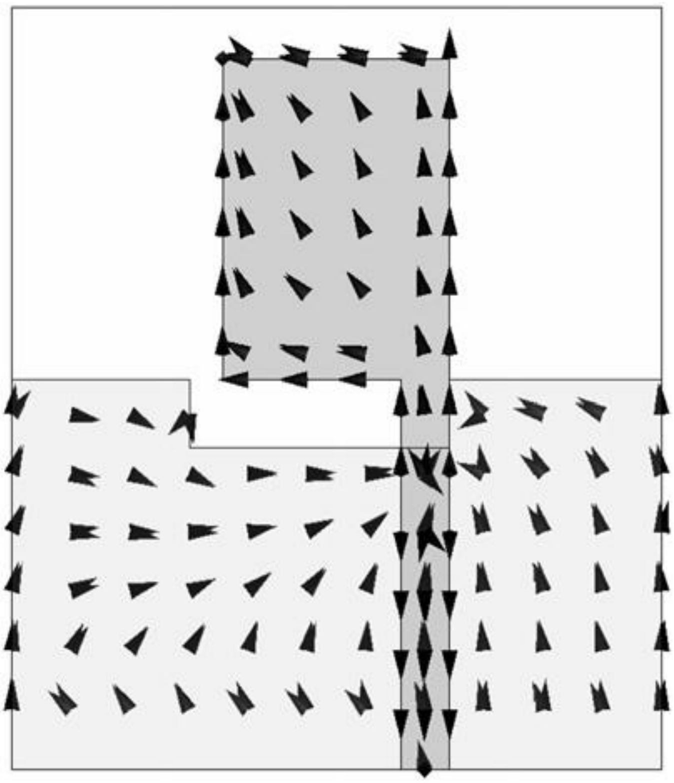

Fig -2: Current distributions of embedding a slit on the ground at 3 GHz

Section clears the design methods includes to increase the impedance bandwidth and to generate circular polarization. The simulations were carried out using the finite element method software 'Computer Simulation Tool, CST Microwave Studio.

3 EMBEDDING A RECTANGULAR SLIT ON THE GROUND PLANE

A wide impedance bandwidth and EP generated by asymmetric feeding. To produce CP with two orthogonal currents of equal amplitude and a 90˚ PD, an S1 ×S2 rectangular slit embedded on the ground plane. The performance of the impedance bandwidth and the CP were affected by the dimensions of the slit (S1, S2).

The simulated return losses and AR of the broadside direction results with different rectangular slit lengths (S1) plotted in Fig. 7. With a fixed value for S2, slits with three different lengths – 14, 15 and 16 mm – analyzed. As in Fig. 7a, the S11 parameters from 2 to 4 GHz affected slightly by the length S1. However, the impedance matching was strongly dependent on S1 from 4 to 9 GHz.By matching a high-frequency impedance bandwidth from 5 to 9.5 GHz, S1 length elected to 16 mm. Fig. 8b also shows the AR effects of the slit. The findings clearly indicate that the CP mode frequency not controlled by S1, but that the widest AR-BW could be reached by appropriately adjusting S1. The length of S1 not only matched the high-frequency impedance band from 5 to 9.5 GHz but also tune the AR-BW

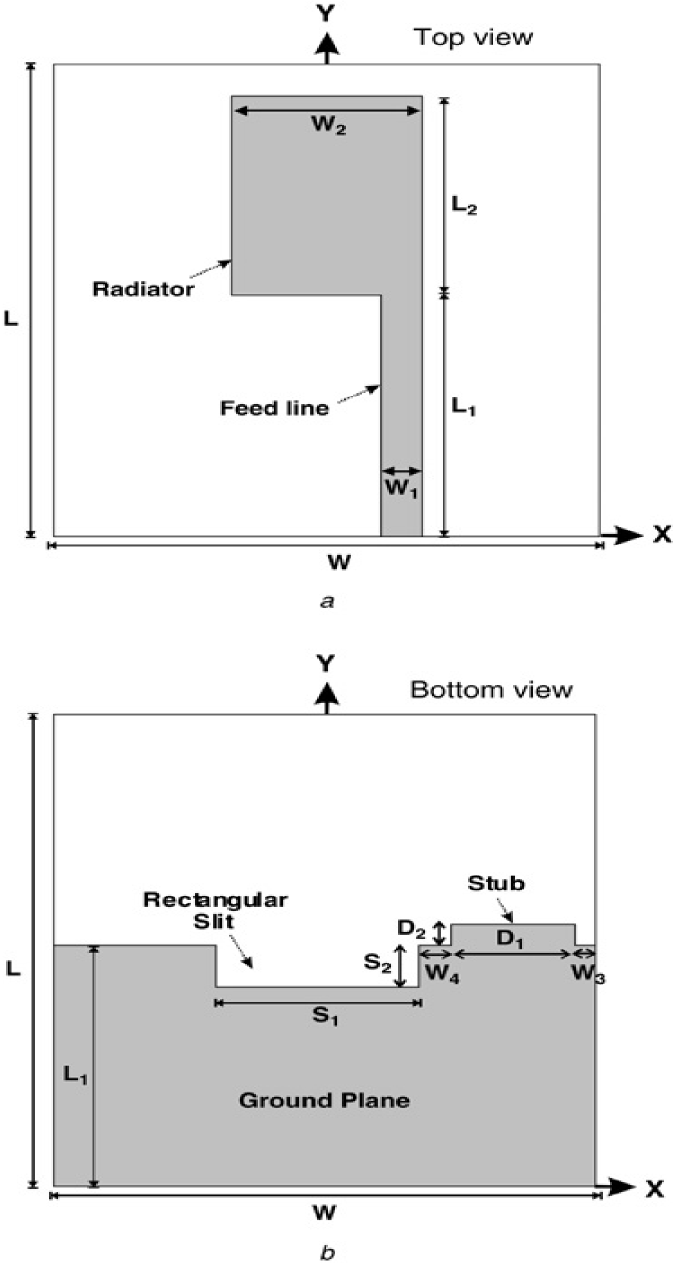

Fig -3: Configurations of the proposed printed monopole antenna
a. Top view b. Bottom view

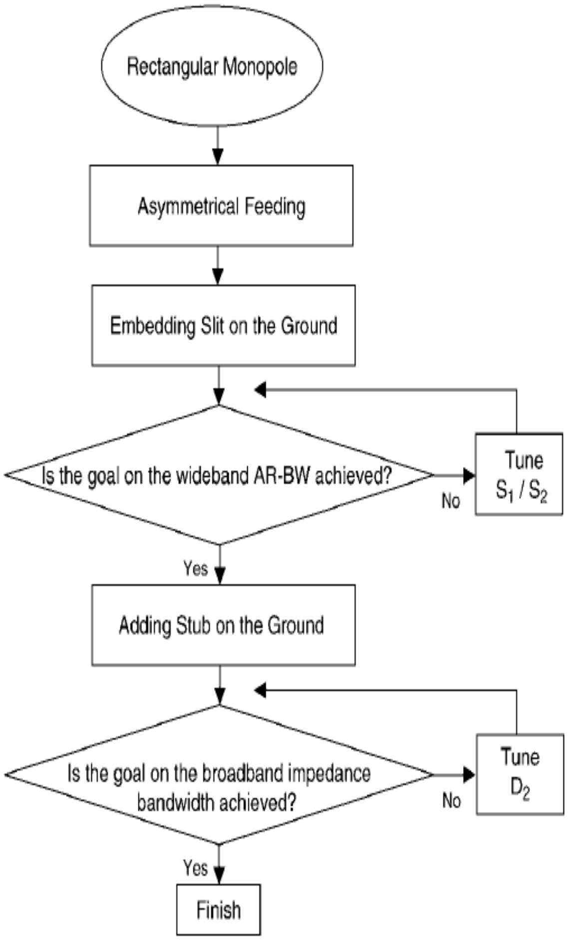

Fig -4: Design flow chart for the proposed antenna

4 EMBEDDING A RECTANGULAR STUB ON THE GROUND PLANE

The rectangular slit shows that it produce extended CP but impedance mismatch from 2 to 4 GHz, thus reducing the impedance bandwidth. To achieve a broad impedance bandwidth and still retain wideband CP, a perturbation stub loaded to the ground plane near a slit. Adding the stub decreases the impedance match. At different stub heights (D2) fig. 9 shows the simulated return losses, and AR results, with the other parameters, fixed. Fig. 9a indicates that the mode at 4.2 GHz was excited as D2 increased. This phenomenon improved the impedance matching of the first mode at 2.35 GHz. With the impedance matching, the stub also affected the CP mode frequency. Fig. 9b shows that the CP mode frequency could tune by using different values for D2; however, the AR bandwidth was independent of D2. A comparison was between Fig. 8b with Fig. 9b that the CP mode frequency was still mainly controlled by the slit height (S2). Based on these simulated results for asymmetric feeding with a ground plane embedded with a slit and stub, this work concludes that using asymmetric feeding enhances the impedance bandwidth and excites the EP radiation pattern. The slit inserted on the ground plane generates CP radiation waves but causes impedance mismatching in the band from 2 to 4 GHz. Adding a stub to the ground plane excites a new mode to match the impedance from 2 to 4 GHz, and only slightly affects the CP mode characteristic. Therefore a broad impedance bandwidth and large AR bandwidth can be simultaneously attained by exactly adjusting the sizes of the slit and stub.

Figure 4 Design flow chart for the proposed antenna

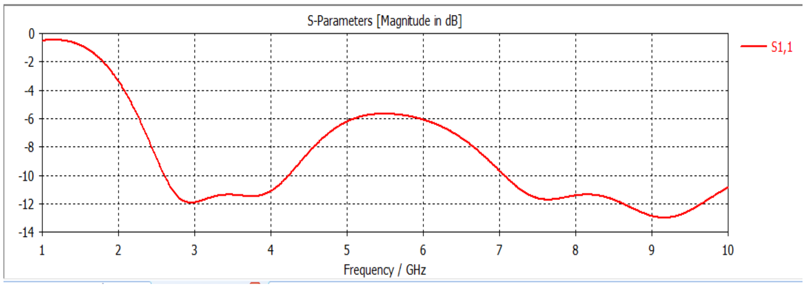

Fig -5a: Central feeding return loss

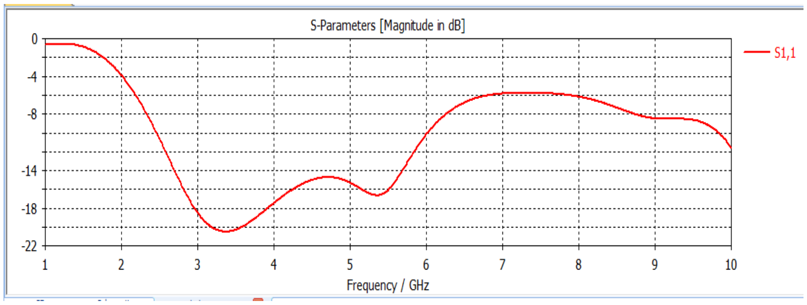

Fig -5b: Asymmetric feeding return loss

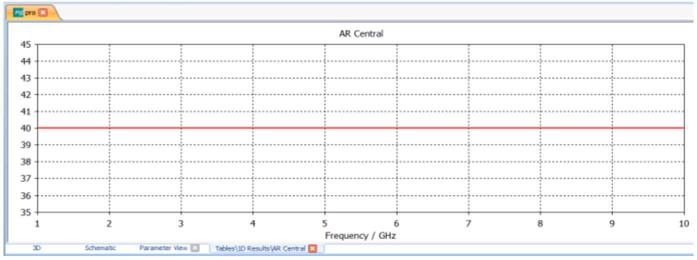

Fig -6a: Central feeding axial ratio

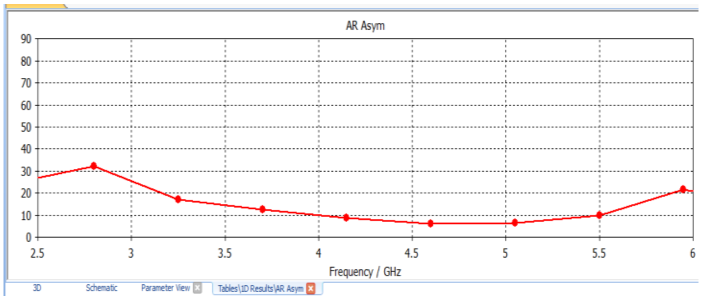

Fig -6b: Asymmetric feeding axial ratio

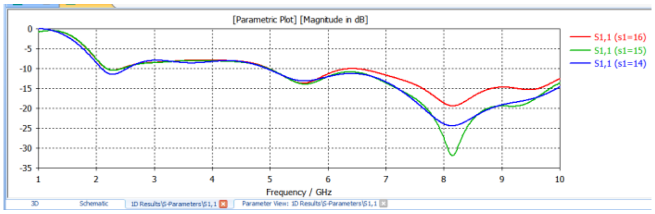

Fig -7a: Simulated return losses of rectangular slit length

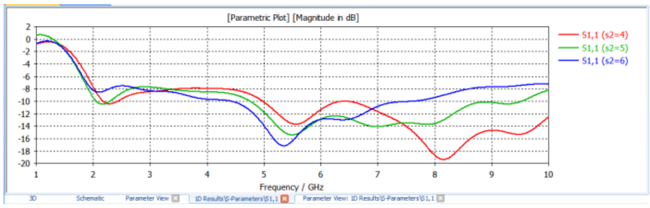

Fig -8a: Simulated return losses of rectangular slit height

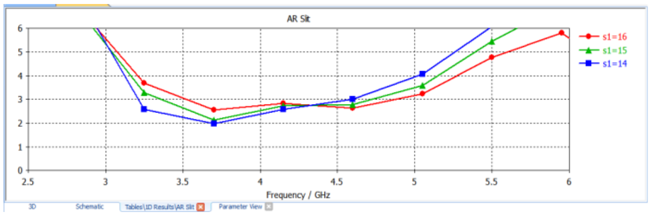

Fig -7b: Simulated axial ratio of rectangular slit length

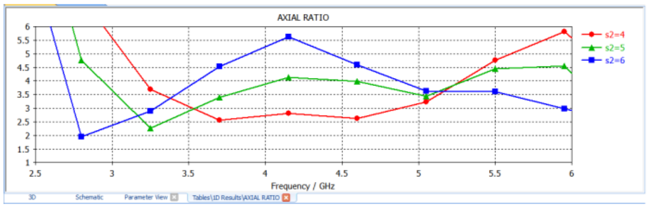

Fig -8b: Simulated axial ratio of rectangular slit height

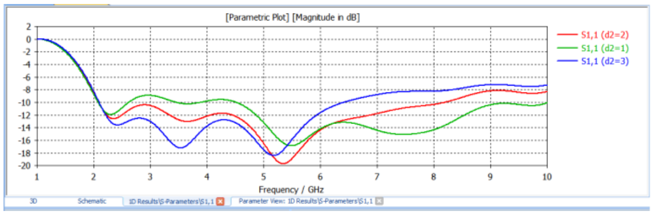

Fig -9a: Simulated return losses of stub height

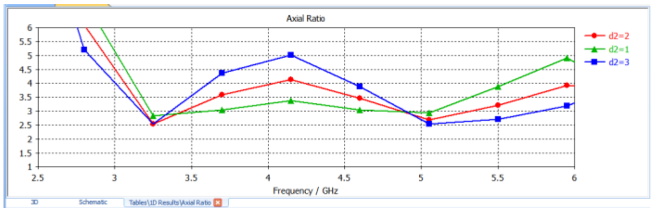

Fig -9b: Simulated axial ratio of stub height

Parameter	Dimension	Parameter	Dimension
L	45mm	W	40mm
L1	23mm	W1	3mm
L2	19mm	W2	14mm
S1	16mm	W3	1.5mm
S2	4mm	W4	1mm
D1	10.5mm	D2	2mm

Table 1. Dimenssions of proposed antenna

5 CONCLUSION

In this study, realizing a broad impedance bandwidth and wide AR bandwidth. It sees that asymmetric feeding modified the radiation from linear to the elliptical and improved bandwidth of impedance. A rectangular slit on the ground plane generates a wide CP and bounded with the CP frequency. A rectangular stub to the ground increases the impedance bandwidth and slightly changes the CP. This antenna provides various applications for a wireless communication system, such as simple structure, easy fabrication, less production cost, large impedance bandwidth, low weight and CP radiation.

REFERENCES

[1] Hsu S.H., Chang K.: 'A novel reconfigurable micro strip antenna with switchable circular polarization', IEEE Antennas Wirel. Propag. Lett., 2007, 6, pp. 160–162

[2] Wan K.C., Xue Q.: 'A novel reconfigurable wideband circularly polarized transmitter implemented by indirect t controlled- phased-source', IEEE Antennas Wirel. Propag. Lett., 2007, 6, pp. 604–607

[3] Richards W.F., Lo Y.T., Harisson D.D.: 'An improved theory for microstrip antennas and applications', IEEE Trans. Antennas Propag., 1981, 29, (1), pp. 38–46

[4] Lo Y.T., Engst B., LEE R.Q.: 'Simple design formulas for circularly polarized microstrip antennas', IEEE Proc. Microw. Antennas Propag., 1988, 135, (3), pp. 213–215

[5] Lee S.K., Sambell A., Korolkiewicz E., Ooi S.F.: 'Analysis and design of a circular-polarized nearly-square-patch antenna using a cavity model', Microw. Opt. Technol. Lett., 2005, 46, (4), pp. 406–410

[6] Tong K.F., Wong T.P.: 'Circularly polarized U-slot antenna', IEEE Trans. Antennas Propag., 2007, 55, (8), pp. 2382–2385

[7] Stutzman W.L., Thiele G.A.: 'Antenna Theory and Design' (Wiley, New York, 1998, 2nd edn.)

[8] Qin Y., Gao S., Smabell A.: 'Broadband high-efficiency circularly polarized active antenna and array for RF frontend application', IEEE Trans. Microw. Theory Tech., 2006, 54, (7), pp. 2910–2916

[9] Ojiro Y., Hiraguri T., Hirasaw K.: 'A monopole-fed circularly polarized loop antenna'. Proc. IEEE AP- S Int.

[10] Wang C.J., Lin Y.C.: 'New CPW-fed monopole antennas with both linear and circular polarizations', IET Microw. Antennas Propag., 2008, 2, (5), pp. 466–472