DESIGN ANALYSIS OF 5G WIDEBAND FED RECTANGULAR PATCHES ANTENNA USING ANTISYMMETRIC L-SHAPED PROBE FEEDS SYSTEM

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Abstract—

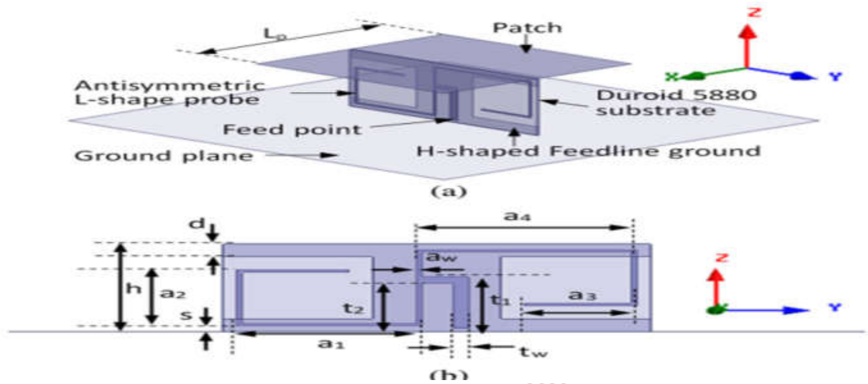
A dual polarized fix antenna element fed by a couple of antisymmetric L-shaped probes is proposed. The planned twin L-shaped probe nourishing structure can acquaint feed capacitance with the antenna for broadband activity. The lengths of the two L-shaped probe feeds are identical yet the feeds are antisymmetric. This sustaining configuration can limit undesirable radiation from the probe effectively. The dual polarized antenna can be worked in the recurrence band 1580-2750 MHz, which covers the present mobile correspondence systems, 3G and 4G and higher band frequencies. A model with dual slanted ±45° polarization has been manufactured for validation. Both the simulated and estimated results demonstrate that the proposed antenna has a wide data transmission of 54% (SWR<2) with desirable directional radiation designs in the vertical and horizontal planes, just as high isolation superior to - 30dB between the two information ports.

Index Terms— antennas, antenna feeds, broadband antenna, dual polarizations, patch antenna, radiation patterns, linearly polarized Unit.

I. INTRODUCTION

As a result of the fast development of wireless correspondence, the 5G (fifth era mobile systems) technology development will be important to satisfy the large system needs. Upgrading mobile system execution capabilities [1]-[4] is a key to facilitate the framework for shrewd city development. Hence, simple structure antennas which give a wide transmission capacity to mobiles and propelled gadgets will have been continuously accepting extraordinary research interests. Over the previous decades, noteworthy advancement has been made in the development of wideband fix antennas. In any case, conventional fix antennas experience the ill effects of thin data transfer capacity, typically only around several rates. Numerous methods have been extensively explored to upgrade the working band of fix antennas [5]-[10]. These strategies can build the transmission capacity dramatically by up to 59%. The methodology is to make an altered nourishing probe with the goal that additional capacitance can be acquainted with the fix for impedance coordinating. The L-shape probe [5], [6], T-shaped probe [9], F-shaped probe [10], wandering probe [7], [8] antennas are the typical examples.

Although these wideband systems can broaden the recurrence band effectively, the radiation from the probes [5], [6], [9], [10] will disintegrate the radiation designs causing high cross polarization, low front-to-back proportion, large gain variety over the band and awry radiation designs in the E-plane at higher working frequencies. So as to enhance the radiation designs and the isolation of the dual polarized antennas, additional power dividers [11], [12], [15], metallic walls [11], [14], [15] or differential feeds [9] must be employed in the fix antenna structure. As a result, the bolstering segment itself together with the power dividers or side walls may lead to the antenna geometry complicated. Alternatively, wideband dipole [16]-[18] and magneto-electric dipole (ME dipole) [19]-[22] antennas have been widely applied in mobile interchanges, however the bulky size and limited beamwidth scope of these antennas are the downsides.



parameter	L_p	h	d	s	t_w	a_w
mm	50	24	3.5	1.5	1.8	0.65
parameter	t_1	t_2	a_1	a_2	a_3	a_4
mm	14.975	13.175	21.72	15.5	13.2	25.93

Fig. 1. Geometry of the antisymmetric L-probe fed antenna. (a) Perspective view (b) feeding structure

In perspective of this, a novel antisymmetric L-probe bolstering strategy is proposed to nourish a fix antenna for broadband task. The sustaining segment is simply imprinted on a low expense printed circuit board (PCB) and no additional hardware or metallic walls is incorporated into the dually polarized case for high isolation between info ports. By utilizing antisymmetric L-shaped probe nourishing, the cross polarization radiation can be decreased while symmetric radiation designs in the principal planes can be acquired. The pillar width can also be balanced with the conventional strategy of changing the fix shape. Models are built and the system is checked experimentally.

II. ANTENNA DESIGN

A. Linearly polarized Unit

The geometry of the antisymmetric L-probes fed fix antenna is appeared in Fig. 1. The detailed elements of the L-shaped probe nourishing structure are illustrated in Fig. 1 (b). The square fix is located over the metallic square ground plane by h=24 mm. The side length of the square ground is 200 mm. In the creation, the fix is bolstered by four plastic spacers at the four corners of the fix, which are not appeared in the figure for curtness. A couple of antisymmetric L-shaped probes is proposed to energize the fix antenna. The feed arrange is realized on a double-sided PCB with permittivity of εr=2.2 and thickness of 0.5mm. One side of the PCB substrate is carved with a H-shape ground plane while the opposite side is printed with a couple of antisymmetric L-shaped probes with feedlines. The PCB is sandwiched between the fix and the ground plane, which is aligned perpendicular to the fix and the ground plane. With respect to excitation, the finish of the feed line is soldered to the internal conductor of a SMA connector underneath the ground, while the external conductor of the connector is appended on the ground plane.

B. Dual linear polarization

The geometry of the dual polarized L-probe fed fix antenna is delineated in Fig. 2. While trying to limit the polarization befuddle loss, the polarizations of the antenna are arranged along slant 45°. In this plan, two sets of anti-symmetric L-shaped probes are respectively carved on Feedline Substrate 1 and Feedline Substrate 2. The point of view perspectives of the two nourishing structures of the two information ports are given separately for clarity. These two bits of PCB dielectric substrates combine at the middle below the transmitting patch. A depression is sliced into each board to half their thickness in order to allow them to overlap each other when joined. Such a course of action allows the convenience of the dual-orthogonal polarization in a minimized territory. Nevertheless, the working transfer speeds at two info ports are diminished. A parasitic fix is accordingly employed in the dual polarized case so as to hold wideband task. The antisymmetric L-shaped probes on Feedline substrate 1 is intended to nourish the fix for - 45° polarization (port 1), while the one on Feedline substrate 2 is for +45° polarization (port 2). The lengths of the upper and the lower patches are Ls = 39.5 mm (0.29 λ0) and Lp = 52 mm (0.38 λ0), respectively. The statures of the upper and the lower square patches are 30.8 mm (0.23 λ0) and 23 mm (0.17λ0), respectively. It is noticed that, in the dual polarized case, the side length of the square ground is only 120mm (0.88 λ0) for shortening the simulation time.

C. Working Principle

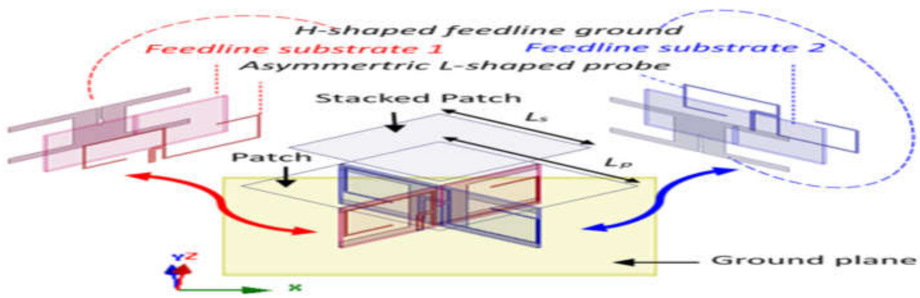


Fig. 2. Geometry of the antisymmetric L-probe fed antenna for dual polarization

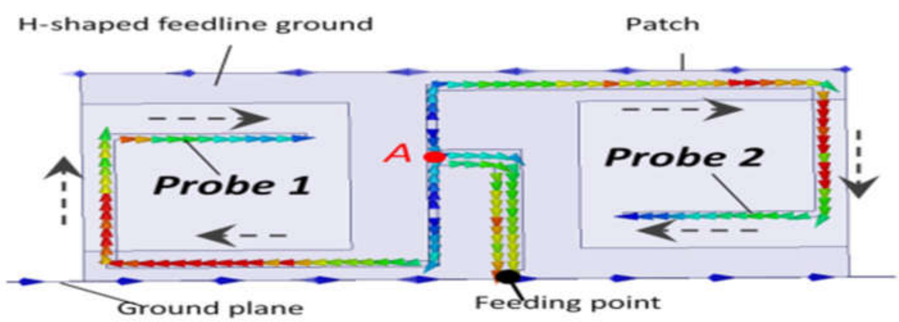


Fig. 3. Side view of current distribution and current flow on the antenna at certain time

So as to exhibit the working principle of the antisymmetric L-probes bolstering component, the simulated vector current circulation on the antenna is appeared in Fig. 3, which demonstrates the flows flow at a specific time. Since the widths and lengths of the two probes are identical, the present densities and extents on the two L-shaped portions are almost the equivalent. It also illustrates the present flowing in the side perspective of the antenna. As a result of the two probes' positions, the flows on their relating vertical and horizontal bits of the two probes flow backward course. The present flow in Probe 1 and Probe 2 are out-of-stage all the time at all frequencies due to the placement and the equal lengths of the probes. Consequently, the undesirable cross-polarization radiation from the encouraging probe is diminished effectively.

The vertical H-shaped feedline ground plane gives the ground impact to the microstrip transmission line, with the goal that neither differential bolstering probe [13] nor additional power divider [11], [12], [15] is expected to create an enemy of stage impact for the two L-probes. Subsequent to leaving point A, the present flows to probe 1 and probe 2 simultaneously and are always inverse way, which implies that the present flowing on the two probes is always out-of-stage.

III. PARAMETRIC STUDY

The analysis of the antennas was performed numerically utilizing a commercial Finite Element Method (FEM) programming, namely Ansoft High-Frequency Structure Simulator (HFSS).

Since the proposed antenna is simple in structure, only two critical parameters of the sustaining probe are considered in the parametric investigation. Alluding to the geometry in Fig. 1, the critical parameters are the vertical part a2 and the horizontal part a3 of the topsy-turvy L-probes. They play vital roles to accomplish a decent impedance coordinating.

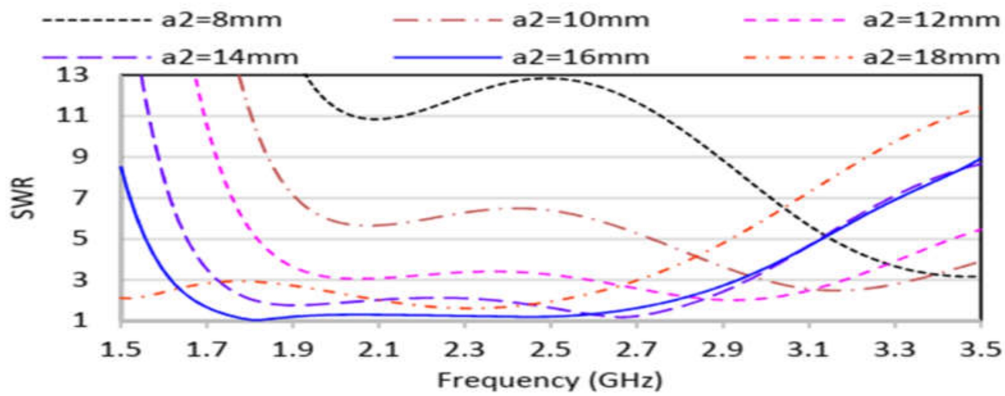


Fig. 4. SWRs along frequency with different a2.

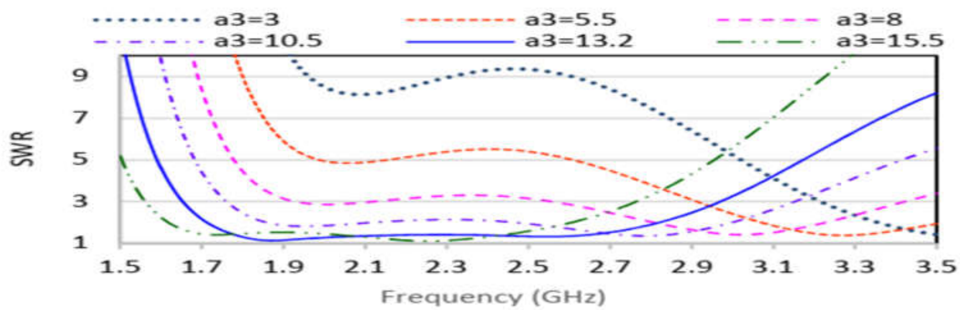


Fig. 5. SWRs along frequency with different a3.

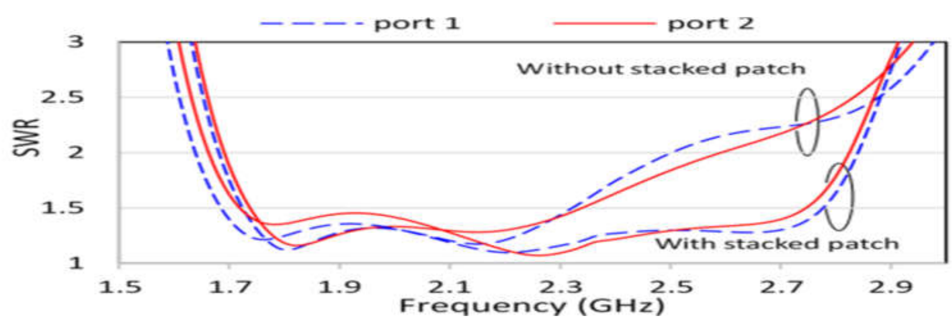


Fig. 6. Simulated SWRs of the dual polarized antenna with and without stacked patch.

IV. ANTENNA PERFORMANCES AND DISCUSSION

For check, models of the antisymmetric L-probes fed fix antennas were produced. The resulting structures can be seen in Fig. 7 and their comparing exhibitions were tried. The S-parameters were estimated utilizing a Network Analyzer, while the radiation examples, additions, and efficiencies were tried in a StarLab Satimo Measurement System.

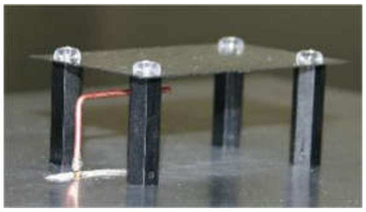


Fig. 7. Prototypes of the fabricated asymmetric L-shaped probe patch antenna.

A. Single Linear Polarization

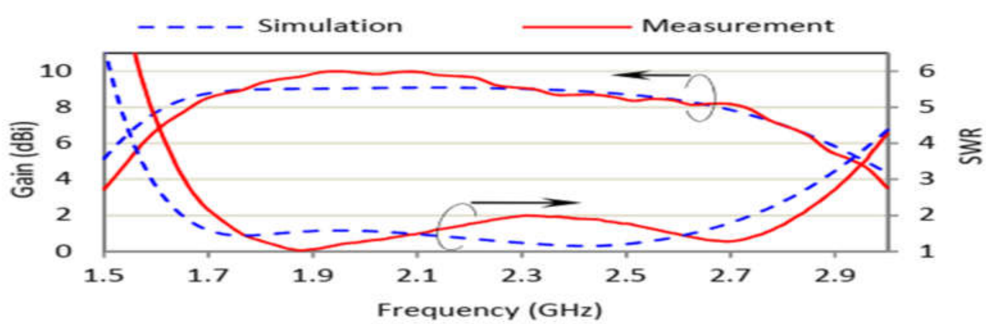


Fig. 8. Gains and SWRs of the linearly polarized antenna..

In Fig. 8, the simulated and estimated SWRs of the proposed antenna are plotted. It is seen that the antenna shows wide

Fig. 4 demonstrates the simulated SWRs with recurrence for various statures of the L-probe a2. Relatively great impedance coordinating is acquired when a2 is longer than 14mm however shorter than 18mm (0.1λ0>a2>0.13λ0). This parameter is directly related to the probe position in the z course, which also implies the arrangement of the inductive part. Fig. 5 demonstrates the variety of SWRs with recurrence for different horizontal length of L-strip a3. The impedance coordinating is enhanced with the expansion of a3. The value of a3 should be around 0.1 λ0 to get wide transmission capacity. The length of a3 speaks to the capacitive part to be given by the L-probes. This capacitive part is vital for a decent impedance reaction. The investigation also demonstrates that the total length of L-strips (a2+a3) should be around λ0/4 for yielding a wideband awry L-shaped probe fed fix antenna.

In the dual polarized case, a parasitic fix is added over the transmitting patch to present an additional reverberation for the impedance coordinating. Fig. 6 demonstrates the SWRs of the antenna with and without the stacked fix. Contrasted with the impedance data transfer capacity of the linearly polarized unit, the upper recurrence of the dual polarized antenna moves down to around 2.5GHz without the upper fix. The nearness of the stacked fix moves the exceptionally capacitive impedance area of the dual polarized single fix to close to a coordinated condition. The upper recurrence of the stacked-fix arrangement moves up to 2.8GHz. Subsequently the dual polarized stacked-fix design has the wideband execution as in its linear polarization partner.

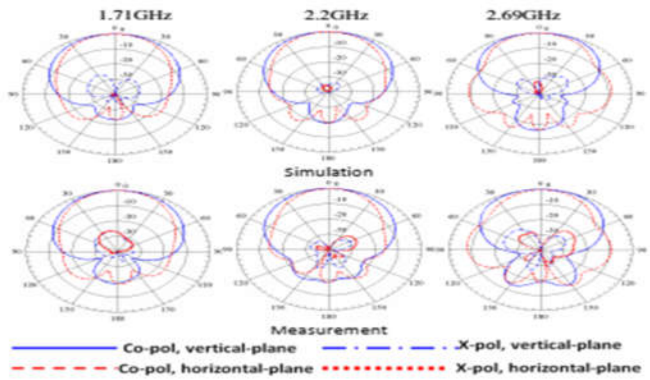


Fig. 9. Simulated and measured radiation patterns of linearly polarized antenna

In Fig. 9, the comparing normalized radiation designs at the 1.71 GHz, 2.2 GHz and 2.69GHz are delineated. Obviously, the antenna has broadside radiations and symmetric radiation designs over recurrence. This structure greatly enhances the high cross polarization in the H-plane contrasted with the traditional L-shape probe fix antenna. Over the working frequencies, both the cross polarization levels in the E-and H-planes are less than - 22 dB. The front-to-back proportion holds superior to 19.5 dB from 1.71 to 2.5GHz, and estimated to 12dB at 2.69GHz. The deliberate half power beamwidth in the H-plane is 76° ± 2° and that in the E-plane is 52° ± 5°, over the working frequencies.

B. Dual polarization

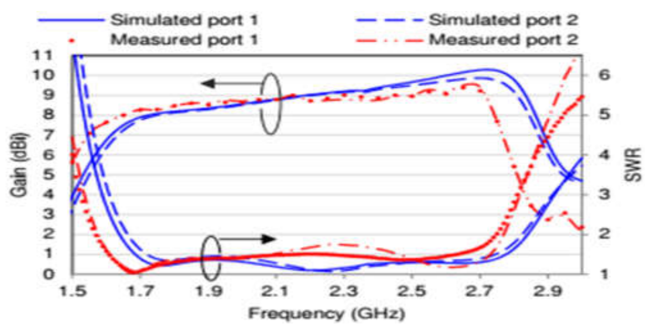


Fig. 10 Measured efficiencies and isolation of the dual polarized antenna for two ports

The simulated and estimated SWRs of the proposed antenna with dual polarization are plotted in Fig. 10. A slightly move to lower recurrence of around 0.3GHz can be found at the two ports, which is mainly because of the creation tolerance. The deliberate and simulated SWRs for the two ports are less than 2 over the transfer speed from 1.58 to 2.75 GHz. The deliberate and simulated additions can also be found in Fig. 10. Over the working frequencies, the increases are higher than 8 dBi, while the deliberate additions at the two information ports are up to 9.5 dBi. At the two ports, it is noticed that relatively higher additions acquired at high frequencies. It is on the grounds that beamwidths gradually diminishes with the expansion of frequencies. The deliberate results are close to the simulated ones. The deliberate isolation between port 1 and port 2 is delineated in Fig. 10.. The isolation over the working band is superior to 30 dB. In addition, the deliberate efficiencies of the two ports are also appeared in Fig. 10. It is noticed that the antenna efficiencies of the two ports are 90% or above inside the whole recurrence band.

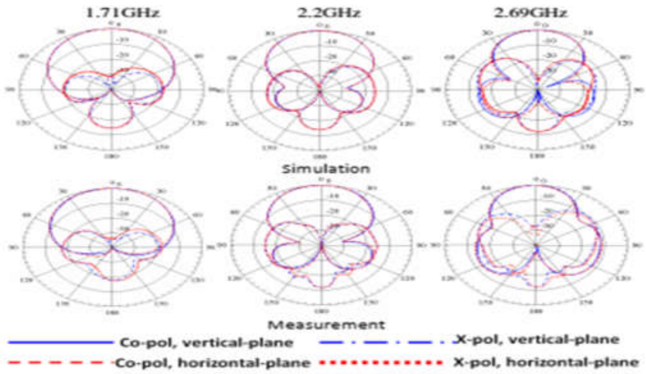


Fig. 12. Simulated and measured radiation patterns of port 1.

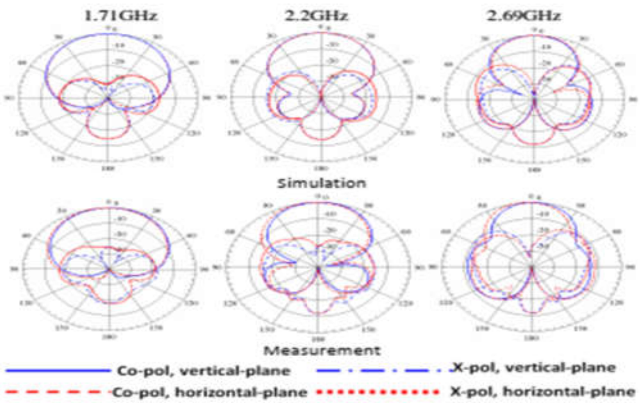


Fig. 12. Simulated and measured radiation patterns of port 2

Fig. 11 and Fig. 12 demonstrate the normalized radiation designs for port 1 and 2, respectively. The examples in the horizontal and vertical planes for the proposed dual polarized antenna are acquired along the 45° planes of the fix antenna (along the diagonals of the square fix). It is seen that the half power beamwidth in the horizontal plane is nearly identical to that in the vertical plane. The antenna shows broadside radiation designs at both information ports. Estimated radiation designs at 1.71, 2.2, and 2.69 GHz well concur with the simulated results. Similar to the exhibitions of the single linear polarization, the antenna demonstrates low cross-polar radiation and high Co-to-Cross proportion at wide angles. The lower the working recurrence is, the

better the cross-polar radiation result is. It is noticed that the radiation designs can't be held at the high frequencies. It is mainly because of the limitation of the fix antenna. Given that the fundamental mode reverberation relies upon the length of the fix, as far as wavelength, the fix length is relatively longer at high frequencies. Similarly, the radiation from the probe ends up huge at high recurrence band. The high cross-polar levels at high frequencies are mainly ascribed to the vertical bits of the L-shaped probe feeds with relatively longer lengths. Nevertheless, the radiation designs are broadside and symmetrical in two principal planes inside the working band.

4.1 Enhanced L-Probe Feeder Structure

The simple L-probe fed structure experiences mongrel rents flowing along the vertical part Lv of the feeder. Their impact develops mainly in higher cross-polar level in the H-plane (YZ cut), see Fig. 10. Also the principle lobe bearing in the H-plane doesn't have its greatest at broadside direc-tion (it is moved by 5° as a result of the structure asymme-attempt). In [6], two out-of-stage fed L-probes are utilized to im-demonstrate radiation properties. Be that as it may, we have discovered a simpler solution which employs a bit of another properly placed vertical wire as delineated in Fig. 11. The flows incited on this auxiliary wire are out-of stage and along these lines partially cancel flows [6] on the Lv part and enhance radiation properties of the whole structure. An additional wire also helps to enhance structure symmetry. Fig. 12

The simulated return loss of the two solutions (classical L-probe and enhanced one with auxiliary wire) is appeared in Fig. 10, the info impedance in Fig. 11. It could be seen that the impedance conduct is almost equivalent to for the L-probe case. The enhanced structure has slightly lower relative BW, 34%, contrasted with 38% of the original a tenna with the L-probe only.

CONCLUSION

In this paper, another wideband nourishing methodology for fix antenna is presented. A couple of antisymmetric L-shaped probes is vertically sandwiched between a square fix and ground plane. The proposed antenna for dual linear polarization is adequate to cover a wide working recurrence band from 1580 to 2750MHz. The high cross-polarization level from the nourishing probe can be smothered effectively with the antisymmetric L-strips. The proposed antenna has wideband, high increase, high proficiency, low cross-polar level and symmetric radiation designs in the two principal planes. Regardless of the radiation results or the structure itself, it is believed that the proposed antenna is superior to or comparable to other wideband directional antennas and favorable for future 5G mobile correspondence applications.

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