A DUAL-POLARIZED SHORTED MICROSTRIP PATCH ANTENNA FOR WIDEBAND APPLICATION

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Abstract

A new design of a wideband dually-polarized shorted microstrip patch antenna coupled to hook shaped probes is presented. The antenna is designed to operate around 4 GHz. The mechanisms of the shorted microstrip patch antenna provide wider impedance bandwidth over 37%. The shorted patch is smaller than as with to the unshorted patch. The present design provides about 40 dB isolation level between the two ports. Also, a stable low cross polarization level is around -20dB for both *E*-and *H*-planes.

***Index Terms* ─ Dual polarization, wide bandwidth, high isolation, shorted microstrip antenna.**

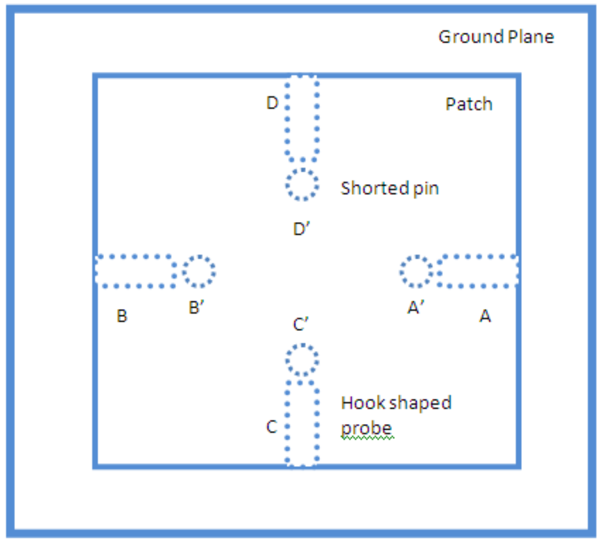
1. INTRODUCTION

Many applications require dual-polarized operating antennas including airborne-based synthetic aperture radar (SAR), and wireless communication. Dual polarized antennas excite two orthogonal modes, which generate the vertically polarized electric field and the horizontally polarized electric field. Therefore, dual polarized antennas add to the body of information by providing two co-polarizations and two cross-polarizations. These antennas reduce side effects of multi-path fading and increase channel capacity per frequency in many applications. Microstrip antennas have good potential for making dual-polarized antennas due to their several attractive features including low profile, lightweight, conformability to mounting structure and compatibility with integrated circuit technology. Much work has been reported to overcome drawbacks of the conventional microstrip antenna such as narrow bandwidth and low efficiency. Furthermore, obtaining high isolations and low cross polarized levels are important and challenging issues for antenna engineers in the design of dual polarized antennas. The main problem of the dual polarized antenna is that two input ports may be coupled to each other to undesired level. This coupling affects the performance of the antenna and may reduce impedance bandwidth and deteriorate the radiation patterns for each polarization. The task is more difficult when it is required to achieve wide bandwidth with highly isolated dually polarized antennas. Momentous efforts have been made to achieve the dual polarized antenna with wide bandwidth, high isolation, and low cross polarization level. The various feeding techniques include aperture coupled feeds with two separated offset slots or crossed narrow slots [1-4], mixture of the aperture coupled feed and capacitive coupled probe feed [5-7], proximity coupled feed [8] and L-shape probe feed without shorted patch [9,10], all of which have been proposed to improve the isolation of the dual-polarized antenna with wide bandwidth. Among them, few designs have been reported to achieve wide bandwidth of more than 30 % [10], and few designs have reported to achieve high isolation of less than around 40 dB with 14% bandwidth [6].

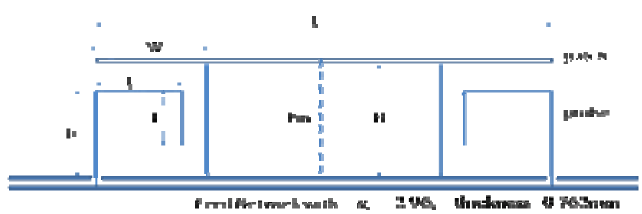
Here, we propose the use of shorted microstrip patch antenna coupled to a hook shaped probe feeding technique for wideband dual polarized microstrip patch antenna with high isolation. The hook shaped probe feeding technique allows reducing the horizontal part length of the probe in order to keep it away from the short pins that improve the isolation between the probes. The extra vertical bend of the hook shape probe compensates the length of the horizontal part of the L shape probe, especially when horizontal probe length is required to be longer than the patch length [11]. The mechanisms of the shorted dual polarized microstrip patch antenna provide wider bandwidth than full size microstrip patch antennas with high decoupling between two input ports. The design and analysis of the antennas are performed numerically using IE3D code [12].

2. Geometry of a dually-polarized shorted microstrip patch antenna coupled to hook shaped probes

The configuration of the antenna is given in Fig. 1. It consists of a square patch with four hook shaped feed probes. The horizontal two hook shaped probes (A and B) have the same magnitude but are in anti phase, and the vertical two hook shaped probes feeds (C and D) have the same operations. The patch with 30 by 30 mm dimensions is supported by four shorted pins of wire radius 0.3 mm and placed 12 mm above the ground plane. Originally, shorted wall patch was the basic geometry of our proposed antenna. However, it required four different shorted patches, similar to those in [11], to achieve the required performance. In the present design the shorted walls are replaced by four shorting pins and single patch. Therefore, the present design is easy to fabricate and consequently cheaper to build. The shorted pins are located at 0^o, 90^o, 180^o, and 270^o with 7.5 mm away from the edge of the patch. Four copper hook shaped probe feeds with radius 0.3 mm are located below the patch and toward center of the patch. The positions of the hook shaped probes are 0^o, 90^o, 180^o, and 270^o and under the edge of the patch. The total length of the hook probe is 18.5 mm with Lh = 8 mm, Lv1 = 6 mm, and Lv2 = 4.5 mm. The feed network below the ground plane is fabricated on a microwave substrate with relative permittivity of 2.94 and thickness of 0.762 mm.



(a) Top view



(b) Side view

Fig. 1. Configuration of a dual polarized shorted microstrip patch antenna coupled to hook shape probes (a) Top view (b) Side view (L=30 mm, W=7.5 mm, H=12 mm, Lh=8mm, Lv1=6 mm, Lv2=4.5 mm)

3. Enhancement of the bandwidth, isolation, and low cross-polarization

It is well known that thick substrate and low dielectric substrate such as air increase the bandwidth of the microstrip patch antenna. L shaped probe feed provide a capacitive effect that is useful in reducing the inductive effect of the probe and consequently widen the bandwidth. Here, the hook shaped with the shorting pin in its proximity increase the capacitive effect and act as an isolator between the several probes used under the patch. Also, introducing the anti phase in each polarization reduces the cross-polarization level within the main beam. The bandwidth of the dual polarized antenna can be enhanced significantly by physically isolating the two feeds of the two polarization that eliminate the direct coupling in the feeding level. The shorted pins provide such isolation. In addition, the anti phase feeding provide symmetry radiation patterns in each plane. Four identical hook shape probes are located at A, B, C, and D. The horizontal probe A and B are excited with the same magnitude but in anti phase, and the vertical probe C and D are also excited in the same manner. Using additional anti phase excitation, the isolation increases significantly, since the current on the vertical parts on A and B are opposite to each other providing cancelation with the vertical parts on C and D. Some papers have reported the relations between shorted patch and large cross polarized level of *H*- plane [13,14]. The distance of the shorted pins between A' and B' is almost quarter wave length and has anti-current flow. Therefore, the radiations of *H* plane cross polarization from the shorted pin A' and B' cancel out each other. In addition, the hook probes between A and B are anti-phase. These processes achieve the low-cross polarized level in the *H* plane.

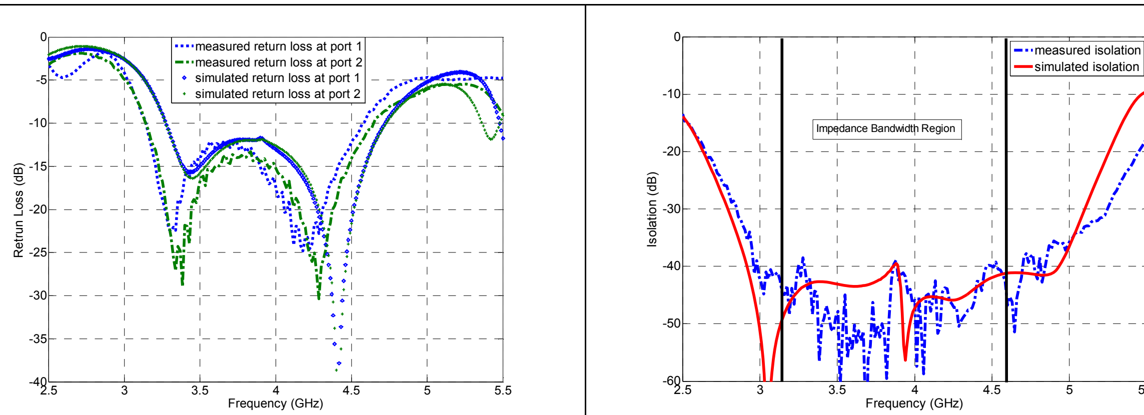
4. Simulated and Measured Results

The performance of the proposed antenna is simulated by using a commercially available method of moment based electromagnetic simulator IE3D and is measured by a HP8510C network analyzer. Fig. 2(a) shows the measured and simulated return loss of the proposed antenna. The measured results are in good agreement with the simulation results. The measured return loss shifts slightly toward lower frequency, but the response is very close to the simulated one. Differences between the simulation and measurement results could be related to the tolerance in the prototype because high degree of symmetry is the key to achieve the required high performance. Measured impedance bandwidth is about 37.3% from 3.14 to 4.58 GHz for port 1, and about 38.8% from 3.14 to 4.65 GHz for port 2. Fig. 2(b) shows the measured and simulated isolation of the proposed antenna. It is observed that the measured isolation is better than 38.5 dB across the entire operating bandwidth. Isolation of dual polarized full microstrip patch antenna coupled to a L shaped probe was reported around 30 dB. Therefore, the performance of the isolation is better when shorted pins are employed.

Fig. 3 shows the simulated and measured radiation patterns at port 1 and port 2, respectively, for the dual-polarized shorted microstrip patch antenna coupled to hook shape probes, at center frequency in simulation (4GHz). The radiation patterns are stable across the operating band. The co-polarization patterns are symmetric, and the cross-polarization levels are around -20dB; These results are achieved due to the anti-phase feed technique and anti-current flow of shorted pin.

5. Conclusion

Dually-polarized shorted microstrip patch antenna coupled to a hook shape probe for a high performance of bandwidth, isolation and cross polarized level was demonstrated. The effect of the shorted pin has not only increased bandwidth performance but also decreased the cross-polarized level, because the cross-polarized level in the *H* plane can be cancelled out by anti-phase shorted pin. The designed antenna achieves a bandwidth of over 37.3% and isolation below 38.5dB. The cross polarized level is around -20dB with stable condition.



(a) (b)

Fig 2. Measured and Simulated return loss (a) and isolation (b) for dual polarized shorted microstrip patch antenna

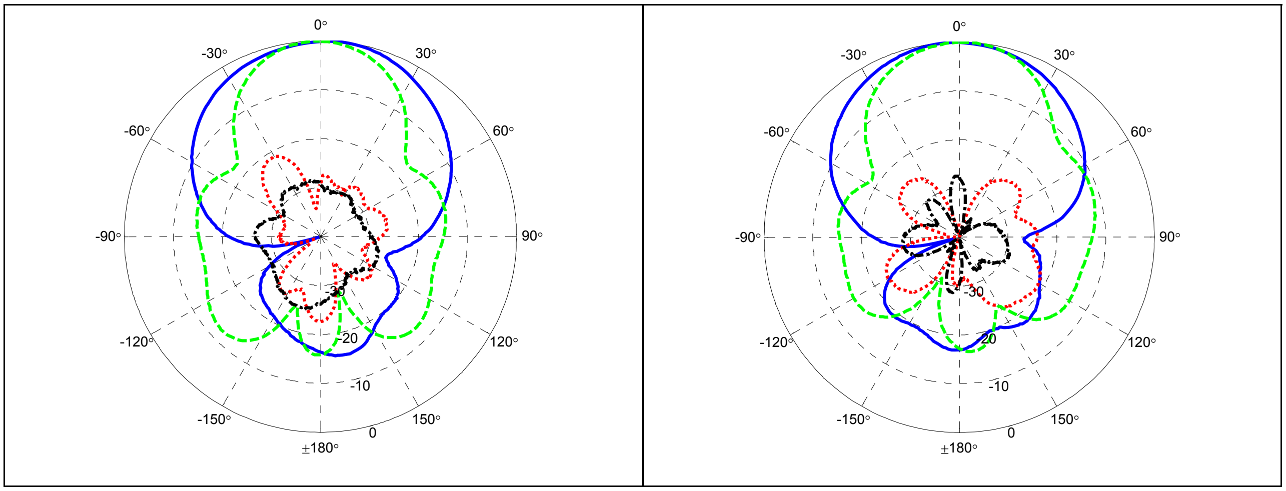


Fig. 3. Measured radiation patterns for port 1and port 2 at 4.0GHz

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