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Dual-Band and Dual-Polarization Patch Antenna with High Isolation Characteristic

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***Abstract*—A patch antenna with dual-band and dual-polarization operation is proposed and discussed. For feeding the antenna, it is used the electromagnetically coupled microstrip-T junction and coplanar waveguide (CPW)-line. Since both ports of the antenna are electromagnetically coupled, the proposed antenna eliminates the need for capacitors in the RF path for active antenna applications. By using CPW resonant cell, the demonstrated approach results in a significant improvement in port isolation.**

***Index Terms*—Coplanar waveguide (CPW) resonant cell, dual-band, dual-polarization, isolation, patch antenna**

I. Introduction

RECENTLY, dual-band and dual-polarization antennas have been studied using different techniques for satellite and wireless communication applications [1-3]. In particular, since microstrip antennas have attractive features such as low profile, light weight, and easy fabrication [4], the antennas are widely used to satisfy demands for polarization diversity and dual-frequency. The simple feeding method is to directly connect, using a microstrip line, to the horizontal and vertical side of the microstrip patch at different operating frequencies. However, a drawback of this feeding method is DC contact between ports through the patch; as well, resonant frequencies can be easily changed according to the position of the inset which has the role of impedance matching. In practice, using this method it is difficult to make reasonable antenna impedance by controlling the position of the inset while maintaining resonant frequencies for the dual orthogonal polarization. In this letter, to solve the above mentioned problems, we propose a CPW-fed aperture-coupled microstrip patch antenna with electromagnetically coupled microstrip-T on the adjacent side of the patch for dual-band and dual-polarization. Since the proposed antenna consists of electromagnetically coupled feeding structures [5, 6], lumped capacitors for blocking DC contact between ports can be inherently avoided. Furthermore, a simple feeding structure for a planar patch antenna is presented by employing a CPW line integrated with a resonant cell. Using the CPW resonant cell providing slow wave and stopband characteristics [7], a high port isolation dual-polarized patch antenna operating a 2 and 2.78 GHz has been demonstrated.

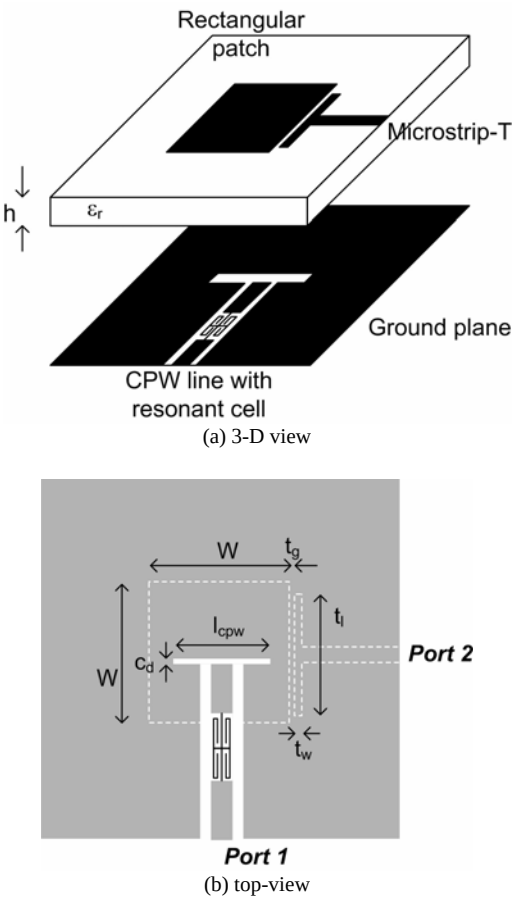


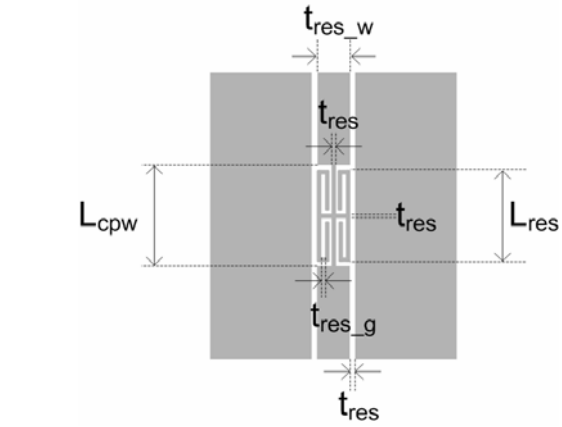
Fig. 1. Configuration of the proposed antenna.

II. Antenna Design

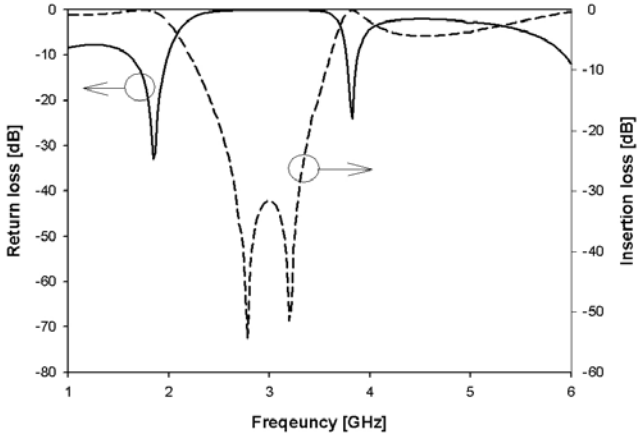
The basic configuration of the proposed patch antenna for exciting dual-band and dual-polarization is illustrated in Fig. 1.

The inner conductor of a CPW feeding structure (port 1) may be connected to the straight coupling slot in a capacitive way, and CPW resonant cell is inserted along the feed line. Since the electrical model of the CPW-fed slot coupled antenna seems to be a series RLC circuit with slowly varying real impedance, the first resonant frequency of 2 GHz is easily determined by adjusting the length (l_{cpw}) of the coupling slot with the same square patch (31 mm x 31 mm). For obtaining the second resonant frequency of 2.78 GHz with orthogonal polarization, the electromagnetically coupled microstrip-T (port 2) is put on

the adjacent vertical side of the patch. Although the patch has the same length and width, the ground plane notched by the CPW-fed line makes it possible to shift up the second frequency. Since the microstrip-T junction acts as an impedance transformer, transforming the high input impedance



(a)



(b)

Fig. 2. (a) Configuration of the CPW resonant cell. (b) Measured S-parameters for the CPW resonant cell.

of the patch antenna to the desired low impedance, using this method it is easy to make reasonable antenna impedance by controlling the gap (t_g) and the length (t_l) of the microstrip-T while maintaining resonant frequencies for dual orthogonal polarization. And we can easily solve the problem of DC contact through the patch because both ports of the proposed antenna are electromagnetically coupled.

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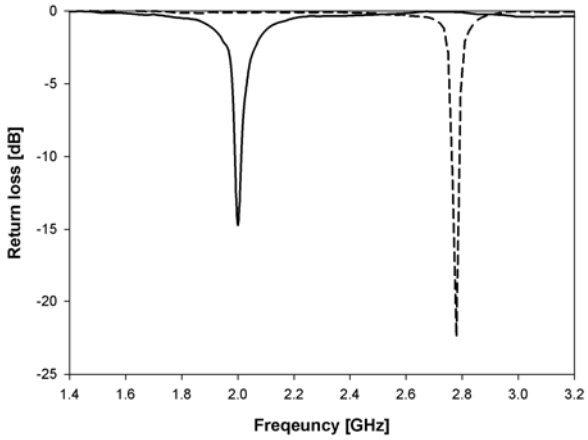
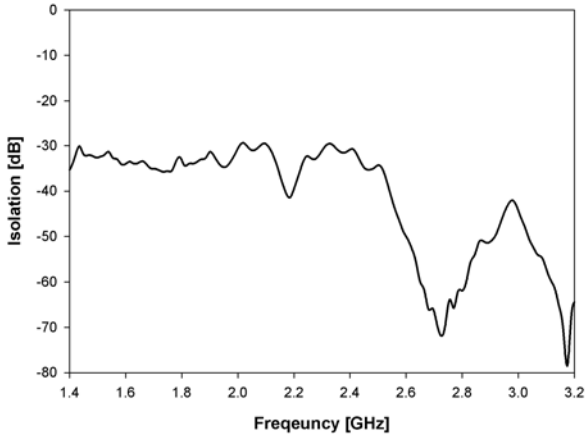
III. EXPERIMENT

The antenna was fabricated on a 1.6 mm-thick FR-4 substrate with relative dielectric constant (ε_r) of 4.6, and measured using an Agilent 8755 Network Analyzer. Fig. 2 shows the simulation result of the CPW resonant cell (L_{cpw} = 14 mm, L_{res} = 13.6 mm, t_{res_w} = 2.2 mm, t_{res} = 0.2 mm, and t_{res_g} = 0.4 mm) placed λ/2, corresponding with 2 GHz, away from feeding point to avoid a variation of the antenna impedance. As shown clearly shown in the figure, the feed line has a stop band at 2.5 – 3.5 GHz. The simulation result implies that high isolation characteristics may be occurred at 2.78 GHz band. The design parameters of the fabricated antenna are: W = 31 mm, t_l = 28 mm, t_w = 0.5 mm, t_g = 0.1 mm, and c_d = 0.8 mm. The measured return loss and isolation characteristics of the proposed antenna are shown in Fig. 3. From the figure, it can be seen that two distinct frequency bands are excited at 2 GHz and 2.78 GHz, respectively. The measured return loss at port 1 was 8 dB less than the original value (-23 dB) of a one port CPW-fed slot antenna due to the variation of the imaginary impedance at port 1 by attaching microstrip-T. Furthermore, it is demonstrated



(a) Return loss (——— port 1, – – – port 2)



(b) Isolation

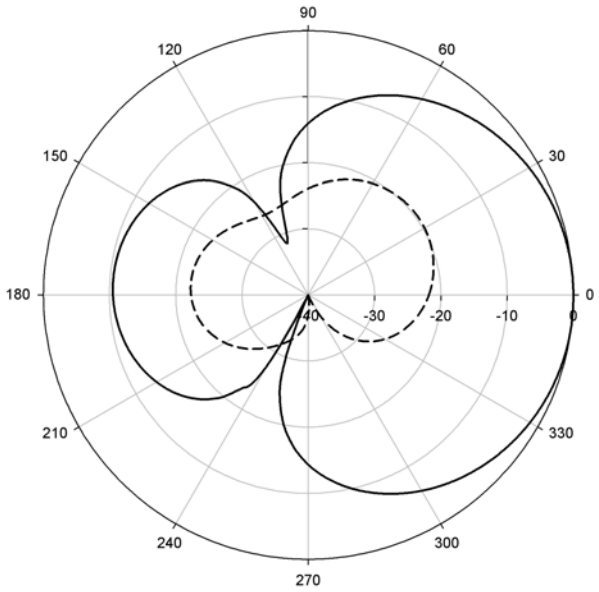
Fig. 3. Measured S-parameter for the dual-band and dual-polarization patch antenna

that the isolation characteristic is suppressed to below –62 dB at 2.78 GHz band.

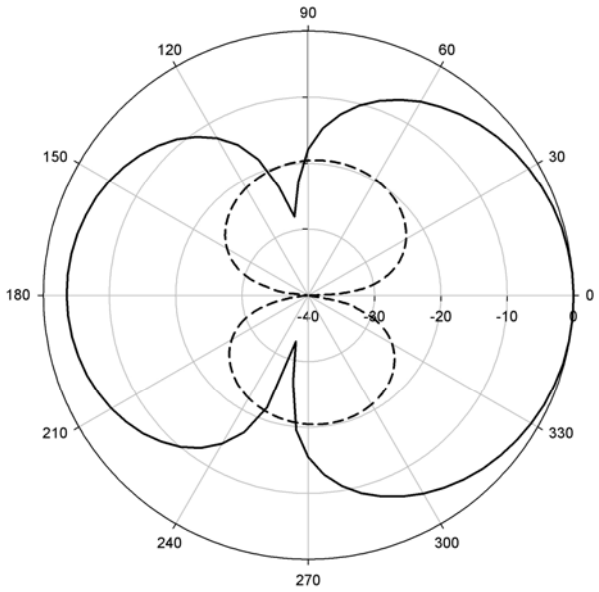
Fig. 4 shows the measured radiation patterns of the antenna at the center frequencies for dual feeding ports. It can be seen from the measured E-plane co-polarization and cross-polarization patterns that they are very similar to the square patch antenna. The radiation pattern is in the broadside direction with a cross-polarization level of 19.8 dB down compared to the co-polarization level. The antenna gains are 4.23 dBi (port 1) and 4.51 dBi (port 2), respectively.

IV. Conclusion

A dual-band and dual-polarization patch antenna based on both the CPW-fed line and the microstrip-T line was fabricated and measured. By attaching a microstrip-T junction in the vertical side of the microstrip patch fed CPW line which is integrated resonant cell, the proposed antenna has the dual-band characteristic. In addition, this antenna has inherent DC isolation because the patch is electromagnetically coupled at both ports. This new type of antenna may be considered promising as an active antenna application which must use both layers.



(a)



(b)

Fig. 4. (a) E-plane radiation patterns at port 1 (2 GHz). (b) E-plane radiation patterns at port 2 (2.78 GHz)
(——— Co-polarization, – – – Cross-polarization)

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