Co-planar Truncated Corner Patch Antenna with Fishbone-Shaped Slot Structure

K. A. Abd. Rashid*, M. N. Husain¹, M. Z. A. Abd Aziz¹, M. M. Saad¹, H. Nornikman#²
Centre for Telecommunication Research and Innovation (CeTRI),
Faculty of Electronics and Computer Engineering (FKEKK),
Universiti Teknikal Malaysia Melaka (UTeM), Durian Tunggal, Melaka,
E-mail: qamarz78@yahoo.com*, nornikman@utem.edu.my#²

Abstract. This work proposed the co-planar truncated rectangular antenna with fishbone-shaped slot structure at the patch for GSM 1.8 GHz and WLAN 5.2 GHz applications. This work provides in six different developments, including a stage from Design A to Design F. Firstly, a basic rectangular patch antenna is done for Design A while the second stage is rectangular patch with cut-out truncated shaped at the bottom part for Design B. Then, it followed by the added co-planar effect for Design C, added fishbone slot structure for Design D, mirror effect of truncated patch for Design E and lastly cut-off triangular truncated corner at the patch for Design F. The performance of proposed antenna of Design F at resonant frequencies of 1.8 GHz and 5.2 GHz is – 25.207 dB and – 16.625 dB, respectively.

1. Introduction

Microstrip patch antennas are the right nominees for numerous wireless applications in the market. Nevertheless, these devices facing several restrictions such as it has low impedance bandwidth and single resonant frequency effect in their initial form. To cater their problem, previous researchers stated several methods to recover these restrictions.

Co-planar waveguide (CPW) is one of the techniques to improve the bandwidth. Besides that, it also potentially has a capability to reduce antenna efficiency and gain, increase end fire radiation, increase cross-polarization levels, and limit the applicable frequency range [1]. Khan [2] in this paper stated that his CPW structure effected the ultra-wideband region between 3 GHz and 9 GHz to his antenna design. Fishbone slot is another technique to create dual or tri band resonant frequency, such as referred at paper by Kang [3]. The other works on the CPW antenna shown in these several papers [4-9].

That antenna operates at two different application of S-DMB range (2.630 GHz – 2.655 GHz) and WLAN application (5.125 GHz – 5.325 GHz). Another works by Liu [8] apply the fishbone shaped slot array on his antenna. Truncated corner is another technique to reduce the size, increase the return loss of the antenna while control the location of the wanted resonant frequency such as in the paper of Mishra [10].

In this work, a co-planar truncated corner patch antenna with fishbone-shaped slot structure had been design with several step developments from basic antenna to the complete fabricated antenna.
2. Antenna Design

Figure 1 represents the co-planar truncated corner patch antenna with fishbone-shaped slot structure development stage that contain six different designs from basic antenna of Design A to the complete proposed antenna of Design F. The design starts with the basic antenna design of Design A. This antenna had a ground plane at the back part. Then, it followed by the Design B that had been cut-out truncated shaped at the bottom part that affect the resonant frequency. For the Design C, the co-planar structure had been effect to give a wideband range to the antenna. Then, it followed by the Design D and Design E that included the fishbone-shaped slot structure into the antenna. The last part is larger cut-out of triangular truncated corner to control the location of the resonant frequency of the antenna.

![Figure 1. Co-planar truncated corner patch antenna with fishbone-shaped slot structure development stage, (a) Design A, (b) Design B, (c) Design C, (d) Design D, (e) Design E and (f) Design F](image)

3. Result

This segment displays the return loss, radiation pattern, surface current, and gain of co-planar truncated corner patch antenna with fishbone-shaped slot structure. Figure 2 and Table 1 show the performance comparison of the proposed antenna. Design A generates three different location of resonant frequency at 2.4 GHz, 4.7 GHz and 5.29 GHz. The first resonant frequencies are effect from the patch antenna itself with −39.451 dB of return loss and 1.020 dB of gain while other two did not give the significant effect performance to the antenna. This is because the first and second resonant had a negative gain.
Figure 2. Comparison of the return loss of fractal patch antenna of Design A, Design B, Design C, and Design D

Table 1. Comparison of the return loss of fractal patch antenna of Design A, Design B, Design C, and Design D

| Design | Resonant frequency (GHz) | Return loss (dB) | Gain (dB) |
|--------|--------------------------|-----------------|-----------|
| A      | 2.4                      | -39.451         | 1.020     |
|        | 4.7                      | -11.060         | -2.243    |
|        | 5.29                     | -10.209         | -1.539    |
| B      | 2.58                     | -14.570         | 1.082     |
|        | 4.77                     | -16.708         | 0.771     |
| C      | 5.4                      | -20.952         | 5.310     |
| D      | 1.8                      | -49.969         | 1.537     |
|        | 5.182                    | -13.787         | 5.224     |
| E      | 1.86                     | -18.782         | 1.494     |
|        | 5.49                     | -15.605         | 5.231     |
| F      | 1.8                      | -25.207         | 1.441     |
|        | 5.2                      | -16.625         | 5.983     |

For Design B, it shows that the truncated shaped at the patch effect to shifted the first resonant frequency to 2.58 GHz with resonant frequency of –14.57 dB. For the second resonant frequency, it shows that the improvement of return loss from –11.06 dB to –16.708 dB. In design C that consist of co-planar technique, the antenna had been achieved the wideband range shape performance but not achieved wanted –10 dB at the first resonant frequency. It only shows the good performance at the second resonant frequency at 5.4 GHz with return loss of –20.952 dB. It shows that also the co-planar technique extremely increases the gain of the antenna to 5.310 dB.

The fishbone-shaped slot structure in Design D is shown to give back the first resonant frequency at 1.8 GHz. The second resonant frequency at this stage is shifted from 5.4 GHz to 5.182 GHz. Then, mirror effect of the truncated patch in Design E illustrate to shifted the first resonance frequency to 1.86 GHz while the second resonant frequency at 5.49 GHz with –18.782 dB and –15.606 dB, respectively. For the last part of the Design F, it shows that the controlled mechanism structure of the cut-off triangular truncated effect to shifted back the first resonant frequency from 1.86 GHz to 1.8 GHz again with
resonant frequency of – 25.207 dB. It also shifted the second frequency from 5.49 GHz to 5.186 GHz with resonant frequency of – 16.625 dB with the highest gain for all design with 5.983 dB.

Figure 3 shows the surface current of fractal patch antenna of Design F at 1.8 GHz and 5.186 GHz. It shows that the main contribution part of the current flow is at the feedline of the antenna and radiate to the patch part. Figure 4 shows the radiation pattern of fractal patch antenna of Design F at different resonant frequency of 1.8 GHz and 5.186 GHz.

![Figure 3](image1.png)  
**Figure 3.** Surface current of fractal patch antenna of Design F at (a) 1.8 GHz and (b) 5.186 GHz

![Figure 4](image2.png)  
**Figure 4.** Radiation pattern of fractal patch antenna of Design F at different resonant frequency of (a) 1.8 GHz and (b) 5.186 GHz

### 4. Conclusion

The simulation work proves that the combination for all technique such as the fishbone-shaped slot, truncated shaped and co-planar give effect to several performances of the proposed antenna. This antenna successfully to use for GSM 1.8 GHz and WLAN 5.2 GHz applications with higher gain at second resonant frequency with 5.983 dB. The best and wanted design are shown by Design F.

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