Point to Point Communication: 5.8 GHz Circular Polarized Proximity-Coupled Feeding Antenna

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Abstract. In this paper, point to point circular polarized 5.8 GHz patch antenna has successfully designed and simulated. This paper presented a design where both of the opposite edges of the rectangular patch of the antenna are truncated using proximity-coupled feeding technique. Both simulations of the proposed antennas had been analyzed. The objectives of this paper has been achieved which is to design and simulate the circular polarized antenna with operating frequency of 5.8 GHz. From the results, the proposed antennas with different feeding technique that radiate at a constant frequency showed some distinct value towards the size of the antenna and the characteristic of its radiation. The results indicate that the antenna that uses proximity-coupled feeding technique yields 3.551 dB directive gain, return loss and axial ratio at -10.015 and 2.225 dB respectively. Meanwhile, the directivity values for the antennas is 5.97 dBi. It can be conclude that by using proximity coupled fed technique, the gain of an antenna can be enhance thus increasing the antenna performance.

1. Introduction
An antenna is a device that is used in wireless communication system for transmitting and receiving a signal. There are several types of antenna that are commonly used in today technology such as Dipole antenna, Helical antenna, Yagi-Uda antenna, Micro strip antenna and Loop antenna. In wireless communication system, the range for wireless coverage and achievable bit rates can be escalated, at the same time decreases the error if the value of the gain of antenna also increases. By matching the polarization for both receiving and the transmitting antenna, an antenna’s gain can become greater. In order to achieve it, both receiving and transmitting sides should have corresponding axial ratio and sense of polarization [1]. But unfortunately it is beyond the bounds of possibility for the spatial orientation of mobile and portable devices to be constantly match as they regularly change their location, thus changing its orientation. To overcome this difficulty, circularly polarized antenna should be used as it is able to match in broad scale of orientation. This is because the radiated waves will oscillate in a circular movement which is at the right angle towards the direction of propagation [2][3].
Micro strip antenna has various conveniences such as it shapes are flexible which enables them to be mount on a hard or firm surfaces. This will likely make them mechanically robust. Micro strip antenna is also light weight and it is affordable as the price is cheap. This type of antenna can be easily made conformal to the host surface as it has a low profile planar configuration. It also supports for both types of polarization, linear polarization and circular polarization [4]. Another advantage for micro strip antenna is that it is capable for dual and even triple frequencies operation [5].

However, compared to conventional antennas, micro strip antenna also has several drawbacks. Micro strip antenna has a narrow bandwidth, a low power gain and low efficiency. Aperture-coupling feeding consists of two different substrates with a common ground plane in between both substrates. The micro strip feed line is located on the bottom side of lower substrate where energy is coupled to the patch where there is a slot cut in the ground plane separating the two substrate. This arrangement allows independent optimization on the radiating element and also the feed mechanism. To enhance the antenna parameter, the slot can be any kind of sizes and shapes. Although by using aperture-coupled feeding technique may increases the bandwidth of the antenna, improves the purity of polarization and also reduces the spurious radiation, but this technique comes with some difficulty as it requires multilayer fabrication [6].

Proximity-coupled feeding consist of two dielectric substrates layers and the micro strip feeding line is located on the top of the lower substrate while the micro strip patch can be found on the top of the upper substrate. The two substrates for this technique can be dissimilar in order to intensify the performance of the antenna [8][9]. This type of feeding technique is also known as the electromagnetic coupling scheme. Proximity-coupled feeding is attractive because this type of feeding technique has the largest bandwidth. It also has the ability to remove spurious feed radiation. Even so, the fabrication process is difficult as it need a very precise alignment for both two layers. In addition, there will be an increase for the thickness of the antenna in general.

2. Antenna Design and Performances

First, a 5.8 GHz circular polarized micro strip patch antenna for point to point communication have been designed by using CST software with specific calculation and formula for the patch and also the feed. Simulation will be done by taking the reading of gain, return loss, radiation pattern, and axial ratio [7]. Verification will be done in order to confirm that the designed antenna had met its criteria. Next, the 5.8 GHz circular polarized micro strip patch antenna will undergo the process of fabrication. The fabrication process will be done by using printed circuit or photolithography technology on a FR-4 substrate. After that, measurement will be taken by using Vector Network Analyzer (VNA). After monitoring session has been done for base station to base station connectivity, all the data will be taken for analysis purposes in order to check if there is an agreement between the simulated and the fabricated results.

The design structure of proposed antenna is consists of rectangular patch with two layer of substrates. This design uses proximity coupled feed method. The radiating patch will be etched on the top of the upper substrate while the feed line is located on the surface of the lower substrate with the ground plane on the bottom of the lower substrate. The geometry of the Proximity Coupled Feed Rectangular Micro strip Patch Antenna is shown below.
Figure 1. Proximity coupled feed patch antenna

The antenna is designed by using CST Microwave Studio and substrate material with a dielectric constant of $\varepsilon_r = 4.3$, while the thickness of the substrates, $h_1$ and $h_2 = 1.6$ mm and with a value of 0.035 mm for the copper thickness. The bandwidth of the proposed antenna can be increase as the radiating patch is placed on the double layer when using proximity coupled feed technique [11]. The first stage is to design the rectangular antenna design with the working frequency of 5.8GHz. The width and length of the patch as well as the Effective Dielectric Constant is calculated using specific formula. For calculation of actual length of patch, $L$:

$$L = L_{eff} - 2\Delta L$$

(1)

The transmission line for proximity coupled was fed at the first layer of the substrate at the left side of the patch to generate Right Hand Circular Polarization (RHCP) in which the electric field vector will rotates in a right hand sense, respect to the direction of the propagation.

Figure 2: Feed line of proximity coupled feed patch antenna

Similar to the micro strip feed patch antenna design, the edge of the proximity coupled fed patch antenna also needs to be cut in order to obtain circular polarization with an axial ratio of $\leq 3$ dB and usually has the range about 2 mm to 10 mm for the cutting edge with 45⁰ of cutting angle. It is calculated that the $\Delta L$ value for proposed antenna is 2 mm. In this antenna design, a slot was also cut at the centre of the patch with at 45⁰ cutting angle.
Figure 3: Side view of proximity coupled feed patch antenna

Table 1 shows the final dimensions after being optimized for the proximity coupled feed patch antenna design. All the parameters are obtained and calculated by using specific equations.

| Parameter  | Value of parameter (mm) |
|------------|-------------------------|
| W          | 10.60                   |
| L          | 10.40                   |
| W          | 3.12                    |
| ΔL         | 2.00                    |
| Slot length| 1.00                    |

3. Simulation results
Return loss is also known as the reflection coefficient represents how much power that is reflected from the antenna. Its value should be less than -10 dB at the operating frequency of the designed antenna because it means that 10% of the incident power is reflected back towards the source. Next, radiation pattern of the antenna represents the graphical of the radiation properties of the designed antenna. It describes the radiation of energy of an antenna that is out into space. It is also important for the antenna to radiate in all directions. The gain of an antenna also plays an important role in designing an antenna. Gain is described as the ratio of the power that is produced by the antenna and how well is the antenna able to convert input power into radio waves in a specific direction [10]. The higher the gain, the higher the performance of an antenna. The most important parameter study for this paper is the axial ratio. It is defined as the ratio that is between the major and the minor axis of the polarization ellipse. If both of the major and minor axis has the same value, the antenna can be claimed as circular polarized as the axial ratio will be equal to 0. By using CST software, the
parameters of the proposed antenna that has been fed by using proximity coupled feed technique were simulated. Figure 4 below shows the value for the antenna return loss versus frequency while Figure 5 shows the axial ratio for proximity coupled feed patch antenna.

![Figure 4. The Return Loss of Designed Antenna](image)

**Figure 4. The Return Loss of Designed Antenna**

![Figure 5. The Axial Ratio of Designed Antenna](image)

**Figure 5. The Axial Ratio of Designed Antenna**

For S-Parameter plot, for the proximity-coupled feed patch antenna, the simulated value of return loss (S11) is -10.01 at 5.8 GHz which is still acceptable. As for the axial ratio, the proposed antenna has a value of 2.22 dB. Both of the proposed antenna design gives a good return loss value at 5.8 GHz. From the radiation pattern plot above, the directivity and the gain of the antenna can be determined. The proximity coupled feed line patch antenna has the directivity of 5.631 dBi and the gain value of 3.551 dB as shown in Figure 6 and Figure 7 below.
Figure 6. The directivity of the proposed antenna

Figure 7: Gain value of micro strip feed line patch antenna

4. Conclusion
As conclusion, the circular polarized 5.8 GHz proximity-coupled feeding patch antenna has successfully designed and simulated. Additional technique of truncated successfully realize the circular polarized antenna with operating frequency of 5.8 GHz. The antenna with proximity coupled feed recorded 3.551 dB directive gain, return loss and axial ratio at -10.015 and 2.225 dB respectively with directivity of 5.97 dBi.
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