Design and Analysis of Squared Patch Antenna with Multi Squared Slots

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Abstract

This study presents the analytical and theoretical investigation on the effect of multi squared slots on resonance frequency, return loss and band widths of a squared microstrip patch antenna. The novel design is achieved by inserting the squared slots in the middle part of the patch antenna. The squared type patch with two or three tiny slots is designed and the reflection coefficient, S-parameter, standing wave ratio, radiation pattern and TDR impedance are analyzed. The performance of the antenna designed is compared with the antenna which has less or more slots. Compared to the conventional rectangular patch antenna, slot loading antennas give the better performance in resonant frequency, return loss in the cost of bandwidths.

Keywords: Resonant Frequency, Slot Patch, SWR

1. Introduction

Microstrip patch antennas are usually used in mobile communication due to their simple structure, easy implementation and low cost. Many efforts have been made to the improvement of the bandwidth and reduction of size\(^1\)\textsuperscript{11}–\textsuperscript{12}. Because of the advancement of technology, microstrip patch antennas are used in a modern communication system, MMIC design, Wireless Local Area Network, radar system. However, according to\(^1\)\textsuperscript{13}, conventional microstrip patch antenna suffers from very narrow bandwidth, typically about 5% bandwidth with respect to the center frequency\(^1\)\textsuperscript{14}. Considerable effort has been devoted to the development and improvement of the bandwidth, return loss and reduction of size. In this article, the resonant frequency and the gain of the patch antenna with two and three slots are analyzed.

2. Slot Patch Antenna Design

2.1 Patch Antenna with Two Slots

Figure 1 shows the rectangular patch antenna with two slots whose dimensions are \(W=28\text{mm}\), and \(L=28\text{mm}\), substrate PTFE (Polytetrafluoroethylene) thickness \(h=1.58\text{mm}\) and dielectric constant \(\varepsilon_r=2.40\), rectangular slot size is \(2.5 \times 2.5\text{mm}\) and each slots are spaced \(10.0\text{mm}\) apart.

![Figure 1. Patch antenna with two slots.](image)

The advantages of the proposed rectangular patch with two slots were simulated using high frequency structure simulator. The results are showed in Figure 2-Figure 6. Figure 2 shows the \(S_{11}\) parameter at the 4.89GHz. Reflection loss for the proposed antenna reaches \(-15.4\text{dB}\) and Figure 3 shows the standing wave ratio 1.48.
Performance has been analyzed and observations regarding the radiation pattern and reflection loss obtained using the proposed patch antennas have been discussed in this section.

Changing the number of the slots make slight performance variation, two slot patch has the better performance than one of three slots. The reflection loss of one or three slots are -13.2dB, -14.7dB, respectively.

Figures 4 and 5 show the simulation results of the radiation patterns for the proposed patch with two slots along E and H planes. The gain of the proposed antenna was found to 2.2dB. This is acceptable value gain for the slot patch antenna.

Also the back lobe of the radiation pattern is quite large due to the ground plane and slot spacing. These can be improved by increasing the area of the ground plane and proper slot spacing.

2.2 Patch Antenna with Three Slots

Figure 7 shows the rectangular patch antenna with two slots whose dimensions are W=28mm, and L=28mm, substrate PTFE (Polytetrafluoroethylene) thickness h=1.58mm and dielectric constant \( \varepsilon_r = 2.40 \), rectangular slot size is 2.5 \( \times \) 2.5mm and each slots are spaced 5.0mm apart.

The advantages of the proposed rectangular patch with three slots were simulated using high frequency structure simulator. The results are showed in Figure 8–Figure 12.

Figure 8 shows the \( S_{11} \) parameter at the 4.99GHz. Reflection loss for the proposed antenna reaches -14.7dB and Figure 3 shows the standing wave ratio 1.45.

Figure 6. TDR impedance of two slot patch antenna.
Figure 7. Patch antenna with three slots.
Performance has been analyzed and observations regarding the radiation pattern and reflection loss obtained using the proposed patch antennas have been discussed in this section.

Figures 10 and 11 show the simulation results of the radiation patterns for the proposed patch with three slots along E and H planes. The gain of the proposed antenna was found to be 2.4 dB. This is an acceptable value gain for the slot patch antenna.

However, the back lobe of the radiation pattern is still large but smaller than two slot patch. It is due to the ground plane and slot spacing, too. These can be improved by increasing the area of the ground plane and proper slot spacing.

3. Conclusion

The proposed antenna design using multi slot patch has been found to give the gain of 2.2 dB at an operation frequency 4.89 GHz. This approach can be extended further to improve gain and antenna performance by proper design the slot structures in patch configuration. A new technique for enhancing the gain and beamwidth of a microstrip patch antenna has been developed and simulated successfully. The simulated results demonstrate that it has a proper beam width at 14.7 dB return loss, 4.98 GHz frequency. The gain of the antenna is not excellent but has satisfactory results. It is assumed that the significant performance improvement of antenna can be achieved by adopting the proposed slot design, slot spacing and antenna feeding then it can make size reduction, better radiation pattern and better antenna gain.

4. Acknowledgment

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5. References

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