Design of Dual Feed Antenna for ultra Wide Band Applications

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Abstract. In this study, a simple architecture of UWB antenna with microstrip patch operating in a frequency range of 3.1 to 11 GHz with dual feed structure is proposed. The compactness and low profile of the designed antenna has gained its importance in commercial and industry oriented applications. The proposed antenna radiates well with good return loss, radiation pattern and gain. The results have been obtained by simulating and testing the proposed antenna. The proposed antenna uses FR4 as substrate. The antenna is simulated using HFSS 13.

Keywords: Microstrip antenna, patch, ultra wideband, feeding, return loss

1 INTRODUCTION

A single feed antenna is one type antenna that radiates or receives radio signal with either vertical or horizontal or circular polarization. In case of a single polarized antenna, polarization is maintained only in a direction where the major portion of radiation pattern lies. Consider in a single feed antenna data is being sent through one port. During the transmission and reception of data, if the channel senses another spectrum to be free, the current transmission has to be stopped to occupy the other spectrum or the channel should wait for the transmission process to get over[1-2]. But during this waiting time it is possible that the spectrum may be utilized by another user or channel. Due to these difficulties a dual polarized antenna is designed. An antenna that can operate in both vertical and horizontal polarization is called as dual feed antenna. Devices in which multithread communication plays a major role can impart this dual polarised antenna so that the devices can transmit data in one mode of polarization and receive data in the other mode of polarization simultaneously. By using multithread communication
the number of antennas required for transmission and reception can be reduced as here only one antenna is used for both transmission and reception which is an added advantage[3-4]. UWB antenna is the one that is designed with size reduction to obtain an omnidirectional pattern with a low distortion but can operate in a wide frequency range. The main advantage of UWB antenna is that, the fading component is much reduced.[5]

2 PROPOSED SYSTEM

The input impedance of 50Ω is fed to the patch by using a microstrip feed line. The structure of the microstrip patch antenna with one feed line is shown in figure 1. The main line has an input impedance of less than 50Ω which is less than 10Ω. The input is given to the feed line through the feed line where the return loss occurs. The structure of the dual feed antenna is shown in figure 2. The designed antenna is simulated using gallium arsenide substrate and fabricated using FR4 substrate. The geometric values of the proposed antenna is given in Table 1 where L1, L2 represent the length of first and second port respectively, W1 and W2 represent the width of first and second port respectively, Ls is the substrate length and Ws is the substrate width[6-7].

Fig. 1. Single Feed Antenna Structure

Fig. 2. Proposed Dual Feed Antenna Structure
Table 1: Geometric Values of the Proposed Antenna

| S.No | Notations | Description         | Dimension in mm |
|------|-----------|---------------------|-----------------|
| 1    | L         | Substrate Length    | 15              |
| 2    | L1        | Length of First Port| 9               |
| 3    | W1        | Width of First Port | 0.7             |
| 4    | L2        | Length of Second Port| 8.5            |
| 5    | W2        | Width of Second Port| 4.3             |
| 6    | Ls        | Substrate Length    | 2.7             |
| 7    | Ws        | Substrate Width     | 0.5             |

3 ANALYSIS OF THE PROPOSED ANTENNA

The microstrip patch antenna performance depends on two primary factors like resonant frequency and dimension. The other antenna parameters like the operating frequency, radiation efficiency, directivity and return loss are influenced by the dimension of the antenna. For an antenna to have good radiation, the patch width can be calculated by using the equation.

\[
W = \frac{1}{2f_{r}\sqrt{\varepsilon_{0}\mu_{0}}} \times \frac{2}{\sqrt{\varepsilon_{r}+1}}
\]

(1)

\[
L = \frac{1}{2f_{r}\sqrt{\varepsilon_{eff}\mu_{0}}} - 2\Delta L
\]

(2)

where

\[
\varepsilon_{eff} = \frac{\varepsilon_{r}+1}{2} + \frac{\varepsilon_{r}-1}{2\sqrt{1+\frac{h}{W}}}
\]

(3)

\[
\Delta L = \frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}-0.8\right)} \times 0.412h
\]

(4)

Characteristic impedance of the patch and impedance of the transition section are given by
\[ Z_a = 90 \frac{\omega^2}{\epsilon_r-1} \left( \frac{L}{W} \right)^2 \]  

(5)

\[ Z_T = \sqrt{50 * Z_a} \]  

(6)

Width of the transition line is given as

\[ Z_T = \frac{60}{\sqrt{\epsilon_r}} \ln \left( \frac{8d}{W_T} + \frac{W_T}{4d} \right) \]  

(7)

Length of the transition line is given as

\[ l = \frac{\lambda_0}{4} = \frac{\lambda_0}{\sqrt{\epsilon_{eff}}} \]  

(8)

4 RESULTS AND DISCUSSIONS

4.1 GAIN

Antenna gain is defined as the ratio of power produced from the transmitting antenna to the power produced by a reference antenna. The reference antenna is usually an isotropic antenna as it senses signal from all directions equally. Gain is usually expressed in decibels (dB) and also referred as decibels isotropic (dBi). The maximum gain obtained is 8.201 dB and 8.184 dB for single and dual feed antenna respectively.

Fig. 3. Gain of a Single Feed Antenna
Fig. 4. Gam of a Dual Feed Antenna

4.2 RETURN LOSS

The impedance mismatch between the load line and the feed line results in power loss. The measurement of this amount of power loss is called as return loss. The return loss value should be maintained as low as possible and the antenna functioning can be further improved if it is a negative value[3]. The resonant frequency of the single polarized antenna ranges between 12.0GHz to 12.20GHz. From figure 5, it is evident that the return loss of the single polarised antenna in the entire range of operation is less than -10dB. The minimum return loss in the operating range is -12dB at 12.25GHz. The resonant frequency of dual polarized antenna ranges from 12.05GHz to 12.45GHz. From figure 6, it is evident that the return loss of dual polarised antenna in the entire range of operation is less than -10dB. The minimum return loss in the operating range is -12.5dB at 12.25GHz.

Fig. 5. Return Loss of a Single Feed Antenna
4.3 RADIATION PATTERN

Radiation pattern describes the strength of the signal transmitted by an antenna in a particular direction or all direction from a fixed distance. For an isotropic antenna, the radiation pattern is same in all directions. The radiation pattern of the proposed antenna is obtained in the E-plane as a bidirectional pattern. The proposed antenna has a good return loss and radiation pattern due to which it can be used in cognitive radio application[1] also operating in the frequency range of 12.0GHz to 12.20GHz for single polarized antenna and 12.05GHz to 12.45GHz of dual polarized antenna.
5. CONCLUSION

The antenna structure is simulated using gallium arsenide substrate and fabricated using FR4 epoxy substrate and a comparison of the obtained results are tabulated. From the simulated results with gallium arsenide substrate, it can be concluded that the designed antenna radiates in E plane with a bidirectional radiation pattern. The operation range is 12.0GHz to 12.20GHz and 12.05GHz to 12.45GHz for single and dual polarized antenna respectively. The minimum return loss in the operating range is -12dB and -12.5dB for single and dual polarized antenna respectively. The gain is improved for the proposed antenna when compared to a normal patch antenna. From the testing result of the fabricated antenna we conclude that the minimum return loss is obtained as -36.64dB and the operating range is 7.6GHz to 12.8GHZ for a single feed antenna. For the dual polarized antenna, the return loss is -42.73 dB and the operating range is 11.6GHz to 12.9GHz for one port and return loss is -23.96dB and the operating range is 11.5GHz to 13.1GHz for the other port.
References

[1] Natasha Devroye, "Information Theoretical Limits on Cognitive Radio Networks" University of Illinois at Chicago, USA (2007).

[2] Boyon Kim, Bo Pan, Symeon Nikolaou, Young-Sik Kim, John Papapolym- erou and Manos M. Tentzeris, "A Novel Single-Feed Circular Microstrip Antenna With Reconfigurable Polarization Capability", IEEE Transactions on Antennas and Propagation, Vol. 56, No. 3 (2008).

[3] Xue-Xia Yang, Bing-Cheng Shao, Fan Yang, Atef Z. Elsherbeni and Bo Gong, "A Polarization Reconfigurable Patch Antenna With Loop Slots on the Ground Plane", IEEE Antennas and Wireless Propagation Letters, Vol. 11 (2012).

[4] E. Ramprasath, P. Manojkumar and P. Veena, "Induction motor analysis using labview", Proceeding on International Conference on Electrical Engineering and Technology, vol. 2, no. 5, pp. 498, 2015.

[5] Shanmugapriya, M, Sivagami S, Sivasakthi B, Prabha K R and Nataraj B, “Design of Microstrip Patch Antenna for WLAN Applications”, International Journal of Advanced Research Trends in Engineering and Technology, vol. 4, Special Issue 7 (2017)

[7] B.Nataraj and K.R.Prabha, “Design of Microstrip Rectangular Patch Antenna for Cancer Detection”, International Journal of Mechanical Engineering & Technology, Volume 9, Issue 13, pp. 935–941 (2018)

[8] B.Nataraj and K.R.Prabha, “Wideband Rectangular Patch Antenna for X-Band Applications”, International Journal of Innovative Technology and Exploring Engineering, Volume-8 Issue-10, pp. 1981-1984 (2019).