A Novel Shape Microstrip Patch Antenna for Bandwidth Optimization with Shorting Pin

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Abstract

Objectives: The aim is to design a Microstrip Patch Antenna (MSA) for enhancement of bandwidth and improved outcome for return loss. The approach for dimension decrease is also a parameter for designing of this antenna. Method: A shorted pin, coaxial feed, Microstrip Patch Antenna (MSA) is used for wireless communication. The patch with U type slot, cut at corner and also shorted by shorting pin is the design of an antenna. For good efficiency proposed antenna’s design parameters are optimized by HFSS’s Optometric. Findings: The proposed antenna has a wide band frequency ranged from 1.4 GHz to 4 GHz with Bandwidth of 210 MHz and 250 MHz return loss of -11.45db and -20.50dB respectively. In this design HFSS (High Frequency Structure Simulator) software is used which is a FEM based electromagnetic solver. The parameteric analysis of return loss, gain and bandwidth is done in an extended form in the proposed antenna design. Application: This design is suitable for the function in wireless communication system and also for fabrication proposes design is very simple.

Keywords: Bandwidth, HFSS, Patch, Return Loss, WLAN

1. Introduction

Antenna plays an outstanding role in designing a private wireless communication device. A perfectly designed radiator makes promising a stable connection, and absolute terminal orientation. It also prevents enormous misuse of energy for the enhancement of efficiency. The requirement for innovative systems and services produced innovative and demanding handset requirements. Designers have faced challenging role for designing an antenna for the handset. The handset should be small, tough, impolring, multi-band, and with extensive battery life1. Wireless communications is developed very fast by this, the microstrip patch antennas are demanding gradually more, which removes its disadvantage day by day and also make its formation and design process progressively complex. Therefore the antenna design problem engrosses a huge number of parameter have a great result resting on the performance of the antenna2. The latest approach allowed the designer to set design goal and then make a aspirant “most advantageous” formation in a systematic and innovative approach. A new promising method is used for full-wave electromagnetic modelling is the combination of codes with optimization methods3. The MSA is considered among the shorting pin and U shaped slot in the projected antenna. To reduce the size of patch antenna there is an efficient way is the shorting pin on its boundary for a fixed frequency. For bandwidth enhancement of an E-shape patch antenna it should be working with the genetic algorithm together. Genetic algorithm works together with Finite Element software HFSS which optimize the structure of the antenna4. Bandwidth expands

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in this case from 6% of the un-optimized one to 16%. The antenna consist a single patch with a resonance frequency of 2.4 GHz and also shorting pin which is situated on the boundary of the patch. For excellent performance the Optimization of the radius of a patch and location of probe feed point from the centre patch is done. Genetic algorithms are hearty, stochastic-based hunt techniques, which can deal with the regular qualities of electromagnetic improvement, issues that are not promptly took care by other optimization strategy. The concept of the genetic algorithm, first dignified by Holland and extensive to functional optimization by De Jong, involves the use of optimal search strategy patterned after the Darwinian principle of natural assortment and development. In GA optimization, a set of testing solutions, or individuals, is chosen and then solved for an optimal solution, below the state of the fitness function. By way of different slots and shorting pin a rectangular microstrip patch antenna, the genetic algorithm is used to optimize in this paper. The factor of the antenna is compute by using Finite Element software, HFSS, of ANSOFT.

Table 1. Dimensions of the microstrip patch antenna

| Variable             | Value   |
|----------------------|---------|
| Width of patch W     | 28mm    |
| Length of patch L    | 33mm    |
| Length of slit c1    | 12mm    |
| Width of slit c2     | 3mm     |
| Length of slot c3    | 4mm     |
| Width of slot c4     | 2.5mm   |
| Horizontal Length of U slot La | 12mm  |
| Vertical length of U slot Wb | 14mm  |
| Width of U slot Wc   | 4mm     |
| Height of substrate  | 0.5mm   |
| Permittivity of substrate | 4.4   |

2. Design and Simulation Result

The present antenna is designed for a centre frequency of 2.4 GHz. The material for Substrate is used FR4 with relative permittivity of 4.4 with the width of 0.5 mm. The U-shaped slot patch antenna is designed with shorted pin for length and width of 28mm x 33mm. In patch dimension which are given in Table 1, there is a fractal shape by cutting the slits on its edge. The four sides of patch cut by a dimension 12mm*3mm slit for all sides this dimension is same. Similarly, there is a slot cut at its all four corners with dimension of 2.5mm*4mm which is given away here in the figure. The slot cut of U shape has the measurement for the horizontal length is 12mm and vertical length is 14mm with the width of 4mm.

Figure 1 and 2 shows the dimension of antenna image in software. Return loss of antenna design shown in the plot of the Figure 3. Bandwidth and return loss calculated as (203MHz, -16.72dB) from the plot at 2.4GHz respectively. Its good quality performance at 2.4GHz frequency is shown by the VSWR of the antenna in Figure 4 which is 1.93.
3. Optimization of Patch Antenna

The best possible result for the antenna is optimized it in a number of ways. The optimization of microstrip patch antenna is done by HFSS software. The Genetic algorithm procedure is used for optimization procedure. The algorithms proceed through the help of the following inputs

1. Maximum no of generations- 20
2. No. of parents -10
3. No. of individuals in the mating pool- 10
4. An individual crossover probability-1 variable crossover probability- 1

Table 2. Outcome of optimization of the microstrip patch antenna

| Variation | Bandwidth   | Length          | Return loss   | Width           |
|-----------|-------------|-----------------|---------------|-----------------|
| 1         | 230.664998321482MHz | 19.209978637043mm | 23.74466852   | 19.214636402748mm |
| 2         | 421.442304757836MHz | 23.480025635548mm | 26.84453871   | 21.7107913449507mm |
| 3         | 417.816705832087MHz | 32.5370647297586mm | 30.07553331   | 39.6142002624592mm |
| 4         | 591.28391369355MHz  | 29.4966887417219mm | 26.22827667   | 19.111438337516mm |
| 5         | 364.909817804498MHz | 34.9844050416578mm | 17.12134159   | 42.819833973084mm  |
| 6         | 414.117862483596MHz | 33.47874385815mm  | 21.6524247    | 35.2654957731864mm |
| 7         | 296.279793694876MHz | 19.586840187139mm | 28.2471694    | 47.5018921475875mm |
| 8         | 596.813867610706MHz | 19.8773676289254mm | 25.96743675   | 18.4104892117069mm |
| 9         | 479.061256048518MHz | 15.8867763298441mm | 23.2231576    | 38.8195898312326mm |
| 10        | 525.754570146794MHz | 15.9397564622944mm | 38.1909998    | 48.9904019287698mm |
| 11        | 559.154026917325MHz | 33.3873104037599mm | 29.9839777    | 28.6185644093142mm |
| 12        | 327.823725089267MHz | 22.910916708396mm  | 24.66734825   | 38.8991515854366mm |
| 13        | 347.148045289468MHz | 36.5020294808802mm | 15.13367107   | 20.7590716269417mm |
| 14        | 381.328775902585MHz | 34.7408736336033mm | 38.95092624   | 28.881420331431mm |
| 15        | 454.28020954009MHz  | 35.015167692096mm  | 43.20459609   | 46.5612506485183mm |
| 16        | 276.906643879513MHz | 32.283272049562mm  | 30.42985321   | 28.0394756920072mm |
| 17        | 378.337961973937MHz | 38.0289199027558mm | 34.66521195   | 39.377592214728mm |
| 18        | 428.949818414868MHz | 37.0027771843623mm | 31.71712394   | 22.4691457869198mm |
| 19        | 439.64354380932MHz  | 39.4167912839137mm | 22.67967772   | 43.2992187261574mm |
| 20        | 334.25702686807MHz  | 28.173099487289mm  | 34.77965636   | 21.0209204382485mm |
| 21        | 366.936246833705MHz | 34.781884217277mm  | 38.61217078   | 29.9721213415937mm |
| 22        | 287.5392258095MHz   | 31.5859859004486mm | 35.81972716   | 39.190266103092mm |
| 23        | 533.396404919584MHz | 41.9060029908139mm | 16.28653517   | 16.553367837035mm |
| 24        | 537.791070284127MHz | 15.749198891263mm  | 38.90972625   | 21.1246528519547mm |
| 25        | 242.445142979217MHz | 40.6994232001709mm | 44.99725333   | 22.7823572496719mm |
| 26        | 301.44352498215MHz  | 15.5945310831019mm | 18.3756233    | 29.7646565147585mm |
| 27        | 263.844721823786MHz | 28.6609698782311mm | 41.25904111   | 32.177649021424mm |
| 28        | 222.986541337321MHz | 35.6765648365734mm | 19.9026521    | 45.10396130253mm  |
| 29        | 419.50327555162MHz  | 23.8295236060671mm | 39.32538835   | 23.3644672994171mm |
| 30        | 285.793633838923MHz | 40.8771629993591mm | 40.55223243   | 30.5723593859676mm |
uniform mutation probability as 0.05 individual mutation probability - 1
5. Pareto front value -10
6. Next Generation parameters, i.e. the no of individuals - 5.

Optimization of the Length (L) and width (W) of microstrip patch antenna has been finished and respectively by the software the bandwidth and return loss too optimized for microstrip patch antenna. The end result of optimization is shown in Table 2.

### 3. Optimized Microstrip Patch Antenna Result and Analysis

In projected design the microstrip patch antenna has been optimized in all the feasible ways to obtain the finest results as given away in Table 2 and from this table at best result will be designed practically which is highlighted. Table 3 shows the dimension of re-designed optimized antenna. Figure 5 shows the software execution of the design.

| Variable         | Value   |
|------------------|---------|
| Width of patch W | 15mm    |
| Length of patch L| 21mm    |
| Length of slit c1 | 11.75mm |
| Width of slit c2 | 2 mm    |
| Length of slot c3| 3 mm    |
| Width of slot c4 | 2 mm    |
| Horizontal Length of U slot La | 12mm    |
| Vertical length of U slot Wb | 12mm    |
| Width of U slot Wc | 1mm     |
| Height of substrate | 0.5mm   |
| Permittivity of substrate | 4.4     |

Table 4. Comparison of parameter in simple antenna and optimized microstrip patch antenna

| Parameters         | Antenna  | Optimized antenna |
|--------------------|----------|-------------------|
| Bandwidth (MHz)    | 203      | 210,250           |
| Return loss        | 16.72    | 11.45, 20.50      |
| VSWR               | 1.93     | 1.52, 1.71        |
| Frequency range(GHz)| 2.4      | 1.4-4             |

By the optimization the optimized return loss of the antenna is 11.45 at 1.45 GHz and 20.50 at 4GHz as shown in Figure 6 and also the bandwidth is completely extended as broadband and its range is 1.45 to 4 GHz. Figure 7 shows the VSWR of optimized antenna which is below 2 at both frequencies 1.45 and 4 GHz. Thus a smallest antenna is designed with a great practical performance, which is also shown in parameter comparison (Table 4).

### 4. Conclusion

The proposed manuscript design optimization technique for microstrip patch antenna which has a novel shape with ‘u’ type slot for broadband applications is triumphantly designed and examined. The MSA designed for enhancing the bandwidth and is optimized with genetic algorithm along with other parameters. A microstrip patch antenna designed for broadband application among
the frequency range of 1.45 to 4 GHz has been presented. The projected rectangular microstrip patch antenna provides high bandwidth of 36.59% and return loss up to 20.50dB. The simulated result shows good performance of designed antenna in practical platform and therefore it can be used in different broadband application such as missile, wireless, satellite, mobile communication and military applications.

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